ROCKFORD INSTRUMENT LAB
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INSTRUCTION MANUAL

MODEL 740
PHASE METER

WAVETEK
SAN DIEGO

9045 BALBOA AVENUE, SAN DIEGO, CALIFORNIA

Serial No. _____

INSTRUCTION MANUAL

MODEL 740
PHASE METER

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REV N-9/78

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SAFETY

This instrument is wired for earth grounding via the facility power wiring. Do not bypass earth grounding with two wire extension cords, plug adapters, etc.

BEFORE PLUGGING IN the instrument, comply with installation instructions.

MAINTENANCE may require power on with the instrument covers removed. This should be done only by qualified personnel aware of the electrical hazards.

WARNING notes call attention to possible injury or death hazards in subsequent operations.

CAUTION notes call attention to possible equipment damage in subsequent operations.

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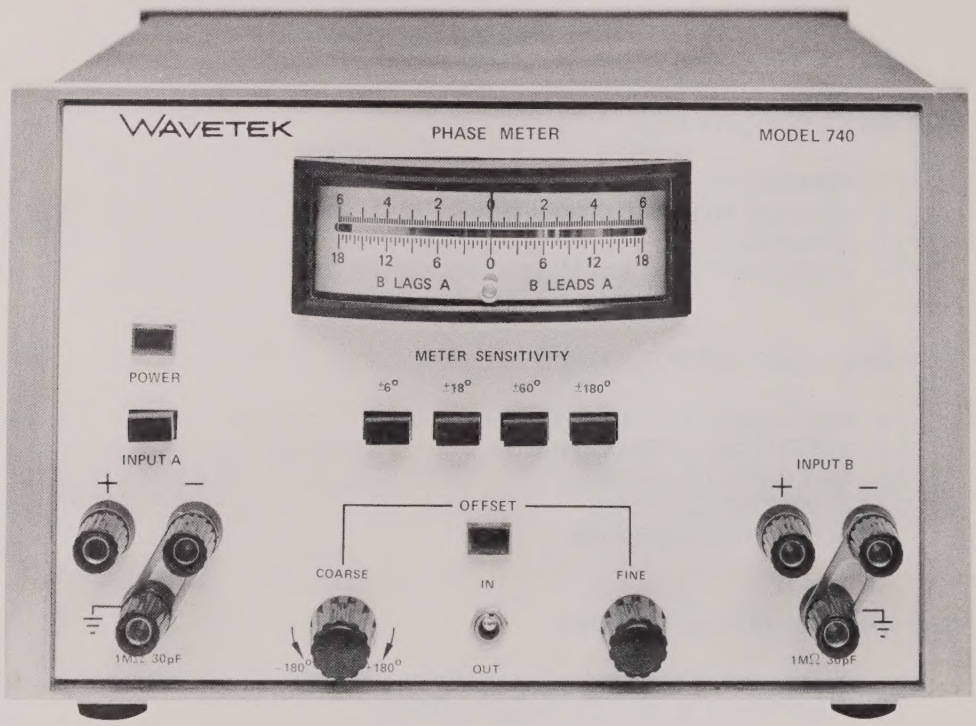


Figure i. Model 740 Phase Meter

SCOPE OF THIS MANUAL

This manual provides descriptive material and instructions for the installation, operation, maintenance, and repair of the WAVETEK Model 740 Phase Meter.

SECTION 1
INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The WAVETEK MODEL 740 PHASE METER has been designed to accurately measure the phase angle between any two ac signals (with an amplitude dynamic range as great as 2000 to 1) within the 10 Hz to 2 MHz range. A precision wideband bench instrument, the Model 740 uses a unique circuit design which permits accurate phase angle measurements with input signals having high even harmonic distortion. A meter with offset capabilities is used to display the phase angle being measured to within 0.1° resolution.

Four ranges (±180°, ±60°, ±18°, and ±6°) allow selection for maximum sensitivity. High impedance differential inputs are used; and a dc OUTPUT −10mV/DEG is provided for use in recording phase angle measurements, or as a control signal for phase lock loops or servo systems. The output is displayed, in degrees and tenths of degrees, directly on a digital voltmeter.

The automatic operation of this instrument eliminates the need for amplitude matching, frequency tuning, and output filtering, resulting in true hands-off operation.

1.2 GENERAL PHYSICAL DESCRIPTION

Weighing approximately 9 pounds (11 pounds when shipped) the Model 740 is 8-1/2 inches wide, 5-1/4 inches high, and 10-1/2 inches deep. Housed in a compact, ruggedized, portable case; the Model 740 is normally shipped with a 10-foot, 3-wire, detachable line cord and one copy of this instruction manual.

1.3 SPECIFICATIONS

1.3.1 Power Requirements

100-130 Vac or 200-260 Vac, 50-400 Hz, less than 25 W, single phase.

1.3.2 Input Signals

Frequency Range . . . . . 10 Hz to 2 MHz

Amplitude Range	Limit
50 mV-50 VOLTS RMS	500 Vdc

Input Impedance
Single-Ended Inputs . . . . . 1 MΩ, shunted by 30 pF
Differential Inputs . . . . . 2 MΩ, shunted by 20 pF

Common Mode Rejection
10 Hz to 100 kHz . . . . . Greater than 50 dB
100 kHz to 2 MHz . . . . . Greater than 40 dB

1.3.3 Output Signals

OUTPUT −10mV/DEG (Standard)
Amplitude . . . . . +1.8 Vdc to −1.8 Vdc
Output Impedance . . . . . 1 kΩ

1.3.4 Accuracy

Absolute Calibration Accuracy
20 Hz to 20 kHz square wave, 100 mV to 5 V p-p . . . ±0.1°

Frequency Effect on Accuracy (100% of Range Sine Wave Inputs)
20 Hz to 20 kHz . . . . . Calibration Accuracy ±.2°
Zero Offset, 10 Hz to 10 kHz . . . . . Less than 0.1°
Zero Offset, 10 kHz to 100 kHz . . Less than 0.1°/10 kHz
Relative Accuracy, 100 kHz to 2 MHz . . . . Better than 2°

Amplitude Effects on Accuracy
Less than 1.5° for 60 dB change on both inputs.
NOTE: Minimum sensitivity below 20 Hz and above 50 kHz is 1% of amplitude range.

Phase Angle Resolution . . . . . 0.1°

Phase Angle Drift . . . . . Less than .2°/8 hours

Response Time (Full Scale Change) . . Less than 4 seconds

NOTES

1. *A faster response time may be ordered (as an option) for measuring fast changing phase angles.*
2. *Phase angle measurements within 2° of the RANGE limits should be avoided; allow ±5° for frequencies below 50 Hz.*
3. *The instrument is designed for use with Tektronix or Hewlett Packard 10X probes.*

1.3.5 Mechanical Characteristics

Dimensions and Weight

Width . . . . . 8-1/2 inches
Height . . . . . 5-1/4 inches
Depth . . . . . 10-1/2 inches
Weight (Nominal) . . . . . 9 pounds
Weight (Shipping) . . . . . 11 pounds

Connector Types

Inputs . . . . . 3 Binding Posts, 3/4-inch spacing
Output . . . . . 2 Binding Posts, 3/4-inch spacing

1.3.6 Environmental Characteristics

Recommended Warmup 1/2-hour

Operating Temperature Range . . . . . 25°C (±5°C)

1.4 ACCESSORIES AND ASSOCIATED EQUIPMENT

The Model 740 is normally shipped with a 10-foot, 3-wire, detachable line cord and a copy of this instruction manual. The items listed below are compatible accessories and associated equipment which may be helpful in the user's installation.

Rack Adapter Kit . . . . . Wavetek No. 130-602

Attenuators, 10 to 1 . . . . . Dual Banana Jack Output
Single BNC Output

Adapters, Dual Banana . . . . . Dual Banana to BNC Plug
Dual Banana to BNC Receptacle

Shielded Test Leads, 36-inch . . Dual Banana to Dual Banana
Dual Banana to Alligator
Dual Banana to BNC

All phase angle measurements are dependent on type of waveform, amplitude, and frequency. The diagrams below show the absolute accuracy, taking into account all sources of error.

ABSOLUTE ACCURACY
100 Hz-100 kHz

ALL ACCURACIES STATED ARE ± DEGREES

CHANNEL A AMPLITUDE PERCENT OF FULL SCALE	.1%	1%	10%	100%
100%	2.4	1.5	0.7	0.4
10%	1.5	0.7	0.6	0.7
1%	0.7	1.0	0.7	1.5
.1%	1.5	0.7	1.5	2.4

CHANNEL B AMPLITUDE
PERCENT OF FULL SCALE

MULTIPLICATION FACTOR
AS A FUNCTION OF FREQUENCY

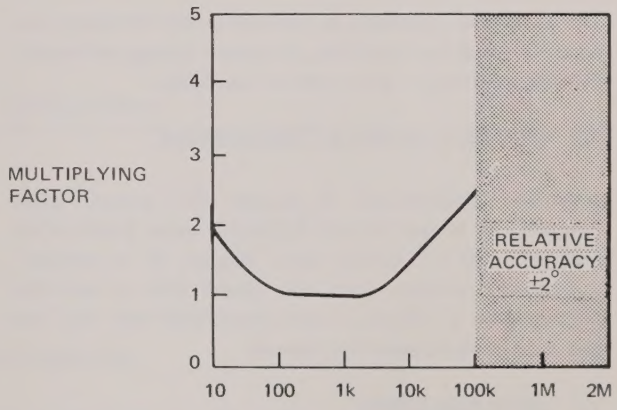


Figure 1-1. Instrument Accuracy Diagrams

SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect the external parts for damage to knobs, indicators, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

No mechanical installation is required when the instrument is to be used as a portable bench unit. If a rack mounting configuration, or a Rack Adapter Kit (see paragraph 1.4), is provided; the unit may be mounted in a standard 19-inch equipment rack. Instructions for attaching the Rack Adapter Kit are provided with the kit.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit and the ac line supply. Check that the proper type of fuse is installed for the line supply being used.

NOTE

Unless otherwise specified at the time of purchase, the Model 740 is shipped from the factory with the power transformer connected for operation on a nominal 115-volt ac line supply. Conversion for 230-volt operation requires resetting a switch at the rear of the unit. To reset the 115/230 conversion switch (concealed by the rear panel) remove the rear panel, set the switch to 230 using a thin-bladed screwdriver, and replace the panel. Install a 1/8-ampere fuse in place of the normal 1/4-ampere fuse.

2.2.2 Input Connections

Connect the desired input signals to their respective connectors using shielded cable equipped with dual banana connectors. Connect single-ended inputs between ground and the appropriate polarity terminal, with the shorting link connected between ground and the opposite polarity terminal. Connect differential inputs between the "+" and "—" terminals, and disconnect the shorting link. See Table 2-1 for input connections and their requirements.

Table 2-1. ELECTRICAL INSTALLATION GUIDE

Symbol	Name	Function
J1	(Line Cord)	Connector for 3-wire line cord.
J2	INPUT A "+"	Connectors for single-ended or differential input signal. The shorting link is used only with single-ended inputs, between a polarized terminal and ground. Observe amplitude specifications and limits of paragraph 1.3.2.
J3	INPUT A "—"	
J4	INPUT A "⏚"	
J5	INPUT B "+"	Connectors for single-ended or differential input signal. The shorting link is used only with single-ended inputs, between a polarized terminal and ground. Use shielded cables with dual banana connectors for these connections.
J6	INPUT B "—"	
J7	INPUT B "⏚"	
J8	OUTPUT —10mV/DEG	Standard output connector.
J9	(Output "⏚")	

2.2.3 Output Connections

Connect the OUTPUT −10mV/DEG to the desired point. Since the OUTPUT −10mV/DEG has an output impedance of 1 kΩ, loading of this output must be considered. This output is short circuit proof and shorting it will not inhibit normal operation. See Table 2-1 for output connections and their requirements.

2.3 INSTALLATION CHECKS

This paragraph outlines a quick checkout procedure for determining proper operation of the instrument. Field calibration and checkout instructions are given in Section 4 for determining if the unit is within all electrical specifications. See Table 2-2 for a description of the functions of the operating controls. No special test equipment is required to perform a checkout of the instrument as outlined below.

1. Connect the line cord to the instrument and the line supply, depress POWER pushbutton, and allow a 20-minute warmup period for the unit to reach a stable operating temperature.
2. Hold CALIBRATE switch (on the rear panel) in the +180.0 position. The meter should display 180°, B lags A.
3. Hold CALIBRATE switch in the −180.0 position. The meter should display 180°, B leads A.

If, after sufficient warmup, the proper readings are not observed, refer to the Calibration Instructions given in paragraph 4.2 of this manual.

2.4 OPERATING CONTROLS

The operating controls and the functions they perform are given in Table 2-2. Additional adjustments, and the functions they perform, are described as they appear in the text of Section 3 and Section 4 of this manual. Do not disturb any control settings, with the exception of operating controls, unless absolutely necessary; and then only if suitable equipment is available for recalibration.

If the equipment appears to operate abnormally, refer to the Calibration Instructions (paragraph 4.2) and the Corrective Maintenance (paragraph 4.3) instructions.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial Installation Checks given in paragraph 2.3 of this manual.

CAUTION

If single-ended ac inputs are used, the shorting link must be connected between the negative and ground terminals. If differential ac inputs are used, the shorting link must be removed and the input signal must be connected between the positive and negative (+ and −) terminals.

CAUTION

To measure the phase angle between any two ac signals (with an amplitude ratio as great as 1,000 to 1) within the specified frequency range, proceed as follows:

Table 2-2. OPERATING CONTROL FUNCTIONS

Symbol	Name	Function
SW1	POWER	Connects ac line voltage to the instrument.
SW2	115/230	Selector for 115-volt or 230-volt operation.
SW6	CALIBRATE	Used as quick check to determine effect, if any, in phase reading.
SW5D	180° RANGE	Selects meter sensitivity of 180° full scale.
SW5C	60° RANGE	Selects meter sensitivity of 60° full scale.
SW5B	18° RANGE	Selects meter sensitivity of 18° full scale.
SW5A	6° RANGE	Selects meter sensitivity of 6° full scale.
SW3	OFFSET I/O	When set to IN, OFFSET may adjust meter.
R101	FINE	Deflects meter ±5°.
R102	COARSE	Deflects meter ±180°.

1. Depress the appropriate RANGE pushbutton to select the range (±180°, ±60°, ±18°, or ±6°) that provides the maximum resolution of phase angle, or use maximum sensitivity (±6°) with OFFSET to obtain 0.1° resolution.
2. Connect one ac signal to INPUT A terminals and the other signal to INPUT B terminals observing the CAUTION notice above.
3. Read phase angle (phase difference) directly on meter. If the meter pointer is to the right of zero, INPUT B leads INPUT A by the measured number of degrees. If the meter pointer is to the left of zero, INPUT B lags INPUT A by the measured amount.
4. OUTPUT −10mV/DEG provides the same data, electronically, for use as a control signal or for general recording applications. The instrument will display the phase angle in degrees and tenths of degrees, when applied to a digital voltmeter.
5. To operate OFFSET:
   A. Set OFFSET switch to IN and, if pointer is far to the right, rotate COARSE control counterclockwise until the pointer is close to zero. If pointer is far left, rotate COARSE control clockwise until pointer is close to zero.
   B. Select METER SENSITIVITY desired, and adjust FINE control for a pointer indication of zero.
   C. For an accurate offset adjustment, connect a digital voltmeter to the dc output and measure the phase angle when the OFFSET switch is set to OUT. Then with toggle to IN position, adjust OFFSET as in steps A and B above. Note change in digital voltmeter reading for precise amount of phase offset on meter.

SECTION 3
CIRCUIT DESCRIPTION

3.1 SIMPLIFIED BLOCK DIAGRAM

As shown in Figure 3-1, the Model 740 Phase Meter consists of two similar input channels and a common output channel. Paragraph 3.2 provides further descriptions of the functions of each basic circuit comprising this instrument. This paragraph describes, briefly, the major circuit elements and their relationship to one another.

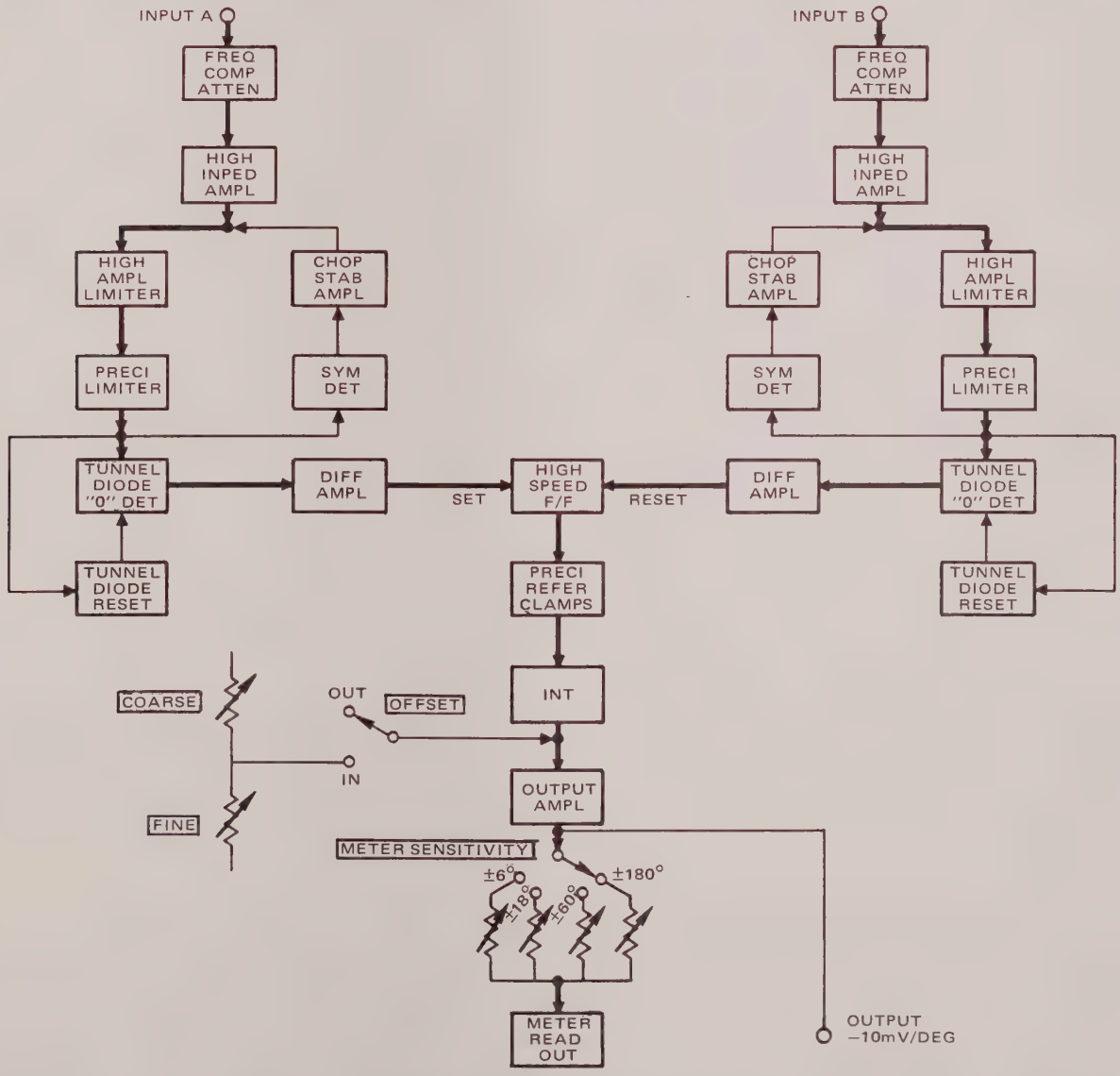


Figure 3-1. Simplified Block Diagram

The Frequency Compensated Attenuator in each input channel is used to reduce high amplitude inputs to a level suitable for the remaining circuitry. The input signal is applied to a High Impedance Amplifier stage, whose function is to isolate the plus and minus inputs and provide high common mode rejection.

Next, the signal is high-amplitude-limited to prevent overdriving in the Precision Limiter stage. The Precision Limiter is a nonlinear feedback, wideband amplifier which limits the input signal at ±5 mV. The limited output signal is applied to a Symmetry Detector which integrates the waveform and produces a dc voltage that is proportional to the symmetry of the clipped waveform. This dc output represents an error in the zero-crossing system or an error due to the distortion of the input signal. The dc level is amplified and inverted in a Chopper Stabilized Amplifier and summed at the input to the first limiter stage. The closed-loop circuitry provides long-term, stable phase detection and automatically balances the limiters to correct for drift or offset voltages in the system due to temperature variations or component aging. Errors due to even-harmonic distortion are essentially eliminated by this self-balancing zero-crossing technique.

Following the limiters, the waveform zero-crossing is detected in a wideband Tunnel Diode Zero Detector. The Tunnel Diode Reset supplies the reset signal to the detector and provides system noise immunity. The detected zero-crossing output is then applied to the High Speed Flip-Flop through a Differentiating Amplifier. The output of Channel A is applied to the "set" input, and the output of Channel B is applied to the "reset" input of the flip-flop.

The flip-flop output is applied to a Precision Reference Clamp stage which provides a signal having an amplitude defined by the reference voltage and a duty cycle proportional to the phase difference between the two input signals. This output is integrated into a dc voltage proportional to the phase difference and is applied to the Output Amplifier for full scale and zero adjustment. The OFFSET is also summed in the Output Amplifier, the output of which is then applied to the output connector and to the range switches of METER SENSITIVITY.

3.2 FUNCTIONAL BLOCK DIAGRAM ANALYSIS

As each functional circuit is described, refer to the appropriate block diagram and, if necessary, the appropriate portions of the schematic diagrams at the rear of this manual.

3.2.1 Zero Crossing Circuit (Figure 3-2 and 3-3)

Both input channels employ similar Zero Crossing Circuits. In view of this, only the functions of Channel A are described, realizing that there are counterparts in Channel B. Figure 3-2 is a functional block diagram of the Zero Crossing Circuit, Figure 3-3 shows key waveforms within this circuit.

The input signal is passed through the Frequency Compensated Attenuator before being applied to Q1-Q2, the High Impedance Differential Amplifier stage. The plus and minus inputs are symmetrically attenuated in the ac/dc attenuator which is adjusted for a flat frequency response by trimmer capacitors C1 and C5.

The input source currents for the High Impedance Differential Amplifier stage are balanced by trimmer adjust R187 to yield rejection. The output of Q1-Q2 is applied to the positive input of Input Amplifier IC1.

Trimmer capacitors C10 and C11 adjust the phase shift of the negative and positive inputs to IC1 to match those of IC4 in Channel B for best high frequency performance. IC1 provides a 180° phase shift. The gain of IC1 is near unity, and its output is applied to the summing junction at the gate of Q3. FET Q3 and transistor Q4 provide a high input impedance to the summing point, as well as temperature compensation. The output from Q3-Q4 is applied to the symmetrical Amplitude Limiter CR1-CR4. R21 is used to balance this four-diode limiter.

The output from CR1-CR4 is coupled to Precision Limiting Amplifier IC2, a 50 MHz amplifier with nonlinear feedback. R28 is a dc balance adjustment, C22 is a phase matching trimmer. The output of IC2 is a clipped waveform having an amplified volts/second relationship at the zero crossing of the input waveform.

For high accuracy, the output of the final limiting amplifier of a zero crossing system must be symmetrical for a sine wave input. To ensure this, the output waveshape must be sampled periodically and the result fed back to the input of the first limiter to correct any unbalance or dissymmetry. The Integrator (comprised of R37-R40 and C26 and C30) supplies a dc voltage proportional to the symmetry of the output of IC2 to the input of Chopper Amplifier IC3. Shunt Chopper Q11 converts the dc output of the Integrator to an ac signal. R64 is the chopper balance adjust.

This ac signal is then amplified in IC3, and the output is demodulated in Series Chopper Q13. The voltage developed across capacitor C59 is an amplified error signal proportional to the nonsymmetry of the output of IC2. This error signal is applied, through R23, to the summing point at the gate of Q3. R82 is a symmetry adjustment which controls the amount of error signal in the feedback loop. This chopper-stabilized symmetry-detection system also elimi-

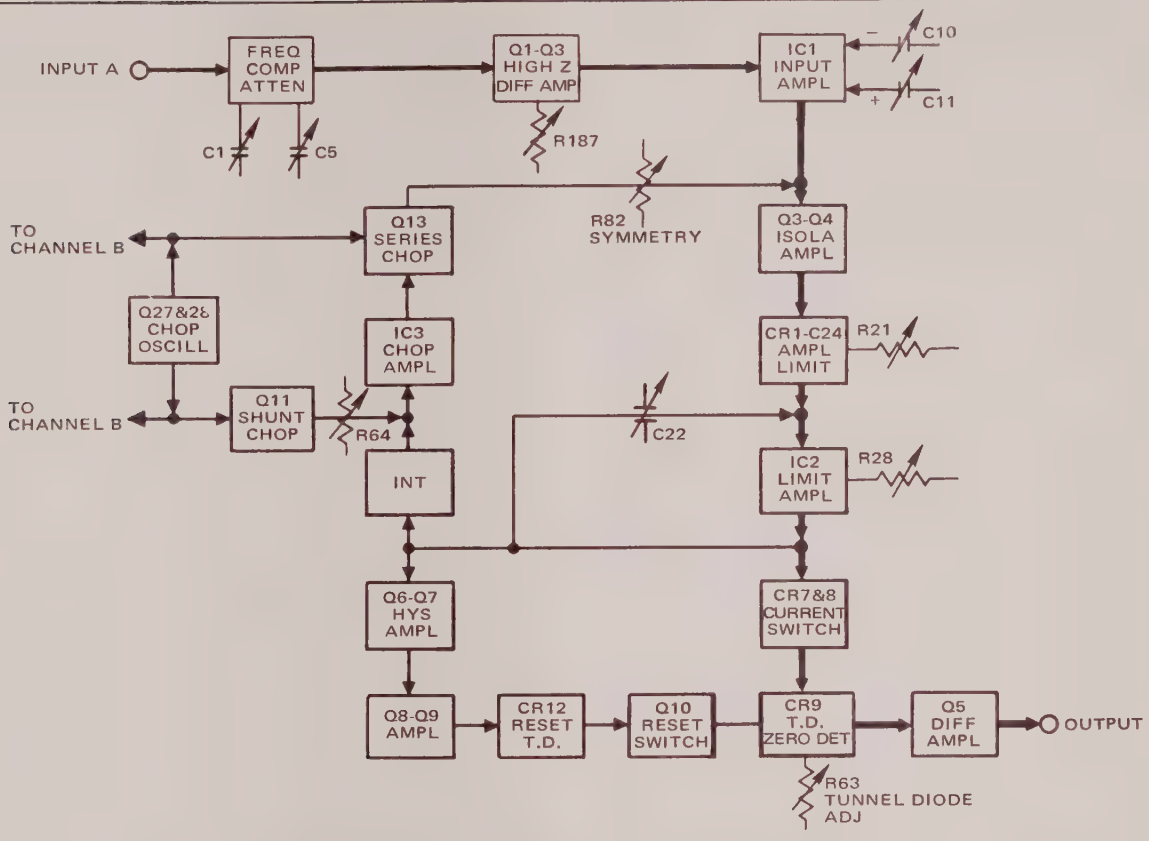
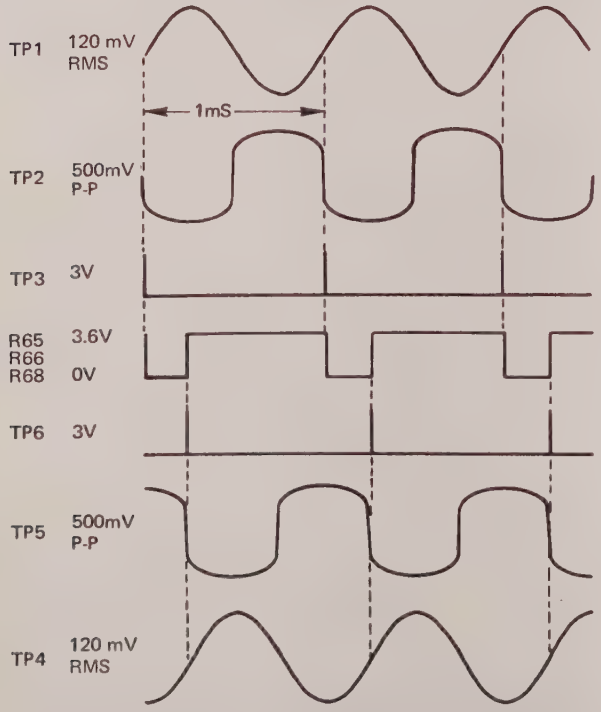


Figure 3-2. Zero Crossing Circuit, Functional Block Diagram



NOTES

INPUTS 100 mV RMS ∿

CHANNEL B LAGS BY 90°

Figure 3-3.
Timing Diagram, Zero Crossing, and Logic Circuit

nates the effects of even harmonic distortion within the limits of the chopper loop.

The symmetrical output of IC2 is then applied to Current Switch CR7-CR8 which supplies a small amount of current, at the actual zero crossing point, to trigger Tunnel Diode Zero Detector CR9. Tunnel Diode Adjust R63 sets the firing point of CR9 to be at the zero crossing point.

Differentiating Amplifier Q5 then supplies a pulse output which occurs at the true zero crossing point of the input waveform.

The reset circuitry for CR9 consists of transistors Q6 through Q10. Hysteresis Amplifier Q6-Q7 amplifies the output of IC2 and provides the necessary hysteresis to prevent double triggering. The output from Q6-Q7 is applied, through Amplifier Q8-Q9, to reset Tunnel Diode CR12. When CR12 fires, the resultant waveform drives Reset Switch Q10 to saturation which, in turn, resets the Tunnel Diode Zero Detector CR9 to its original state.

Chopper Oscillator Q27-Q28 is the circuitry common to both channels of the Zero Crossing Circuit. This oscillator supplies the chopper pulse which drives the gates of field-effect-transistors Q11 and Q13 at the proper sample rate.

3.2.2 Logic Circuit (Figure 3-3 and 3-4)

The Logic Circuit converts the pulse information generated by the Zero Crossing Circuit into a precision, linear dc voltage whose value is a direct function of the phase difference between inputs A and B.

The two pulses generated by the Zero Crossing Circuit are applied to the inputs of a fast rise and fall time Set-Reset Toggle IC4. This stage is a dual transistor gate connected as an RS toggle with hot carrier diodes CR13 and CR14 providing nonsaturated, high speed operation. This stage converts the pulse information into a rectangular waveform that drives Saturated Switch Q18-Q19.

When the CALIBRATE switch is actuated, it inhibits either the "A" or "B" input from the Zero Crossing Circuit. With one input inhibited, the Set-Reset Toggle IC4 will go to a single state and remain. One state of IC4 corresponds to -180°, the other state corresponds to $+180^{\circ}$. Therefore, when CALIBRATE switch SW6 is actuated, all dc calibrations may be checked.

Q18-Q19 operates as a pair of saturated switches between ground and a precision +3.6 Vdc. The resulting output, at the junction of R65 and R66, is integrated in Integrator R68/C24 and then filtered by an active Unity Gain Filter

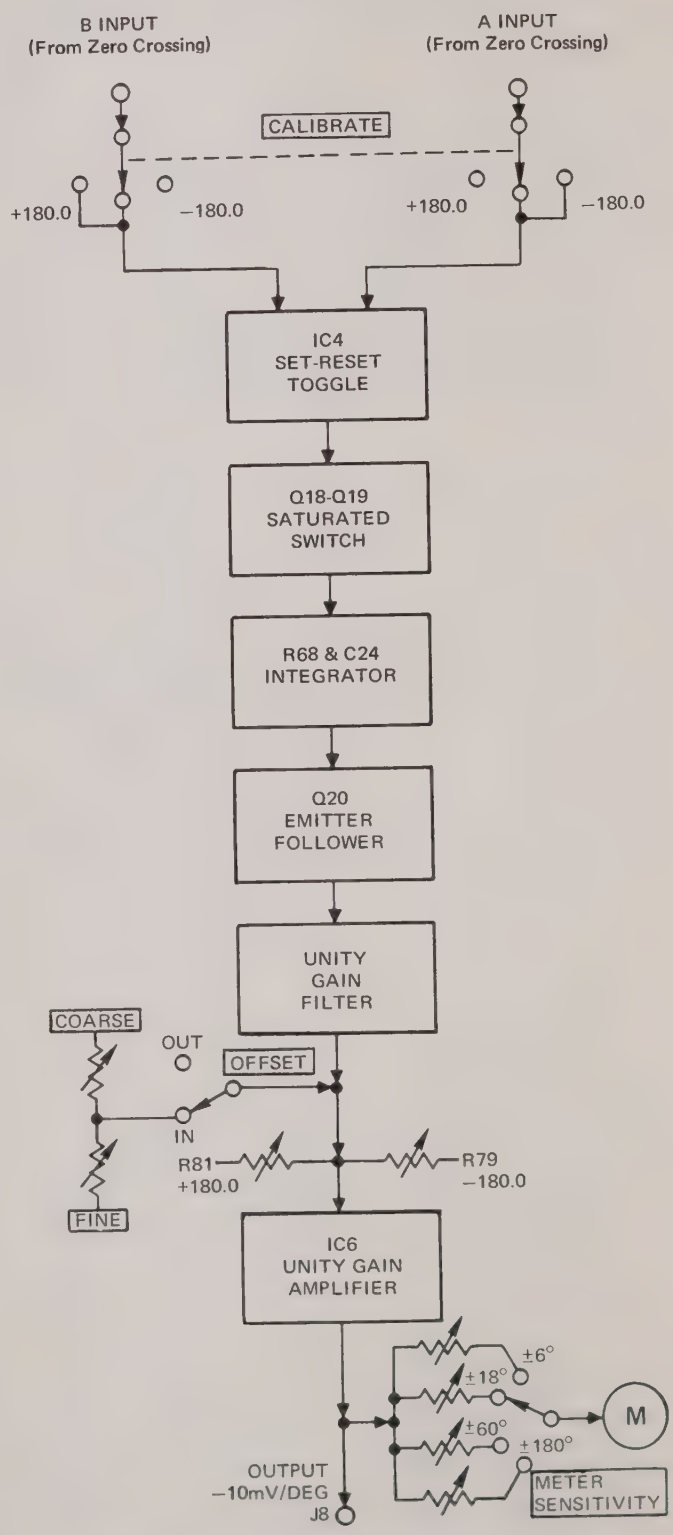


Figure 3.4. Logic Circuit, Functional Block Diagram

comprised of IC5, R69, R70, C25, and C26. Q20 functions as an Emitter Follower input to the Unity Gain Filter.

The integrated and filtered signal, representing the phase angle between INPUT A and INPUT B, is then conditioned in the Unity Gain Amplifier IC6. The final dc voltage out of IC6 has a −10 mV/degree relationship to the measured phase angle, and is provided (at J8) as an output as well as the input to the meter. The phase offset is summed in IC6 and, hence, may be used to offset the phase back to zero for use with maximum meter sensitivity.

Range calibration is accomplished by two potentiometers at the rear of the unit. The +180.0 and the −180.0 limits may be calibrated using R79 and R81 respectively.

3.2.3 DC Power Supplies (Figure 3-5)

Regulated operating voltages for the Model 740 Phase Meter include +15 V, −15 V, +3.6 V, and −3.6 V. Ac line voltage is connected through the line cord to the POWER switch on the front panel. A slo-blo fuse is installed on the line side of the switch, and a 115/230 power selector switch connects the primary winding of the power transformer for the appropriate line voltage.

Ac voltage is coupled from the transformer secondary to the Bridge Rectifier CR1-CR4. Filtering is provided by C3 and C11. Q12 is operated as a Zener diode reference voltage for the −15 V supply. IC3 is a comparator differential amplifier. The Comparator drives a Darlington-connected Series Pass transistor pair, Q9 and Q11, used for added current gain. Q8 is also connected to operate as a Zener diode reference to provide a voltage level shift for the output of IC3. R36, −15 V ADJ, adjusts the minus input of IC3 with respect to the plus input which has a Zener voltage of approximately 7 volts. If the −15 V tries to increase due to a change in line voltage or load current, the collector of Q12 stays approximately at the same voltage. Thus, the minus input to IC3 becomes more positive than the plus input, and the IC3 output draws more current. The output moves less positive, and this change is coupled to the base of Q9 and Q11 through Q8, returning the supply to −15 volts.

IC1 is a Comparator Differential Amplifier in the +15 V supply. The plus input of IC1 is returned to ground through R9. Voltage Divider R7-R8, between the plus and minus 15-volt supplies, sets the minus input of IC1 precisely at ground. An increase in the −15 volts, due to line voltage variation or load current change, results in the minus input of IC1 moving positive, and the output of IC1 moving negative. This change is coupled to the bases of Q1 and Q2 through Q4. Q1 and Q2 form a Darlington-connected Series Pass pair for added current gain. The negative-going change returns the output to +15 volts.

Q3, in conjunction with R2 through R4, comprises a foldback current limiter for the +15 V regulator. Normally, the base of Q3 is turned off. Thus, the base of Q2 moves freely as the output from IC1 changes. When the +15 volt output is overloaded, heavy current flows through R2 and creates a potential drop across the resistor. When the potential drop overcomes the drop across R3, Q3 begins to

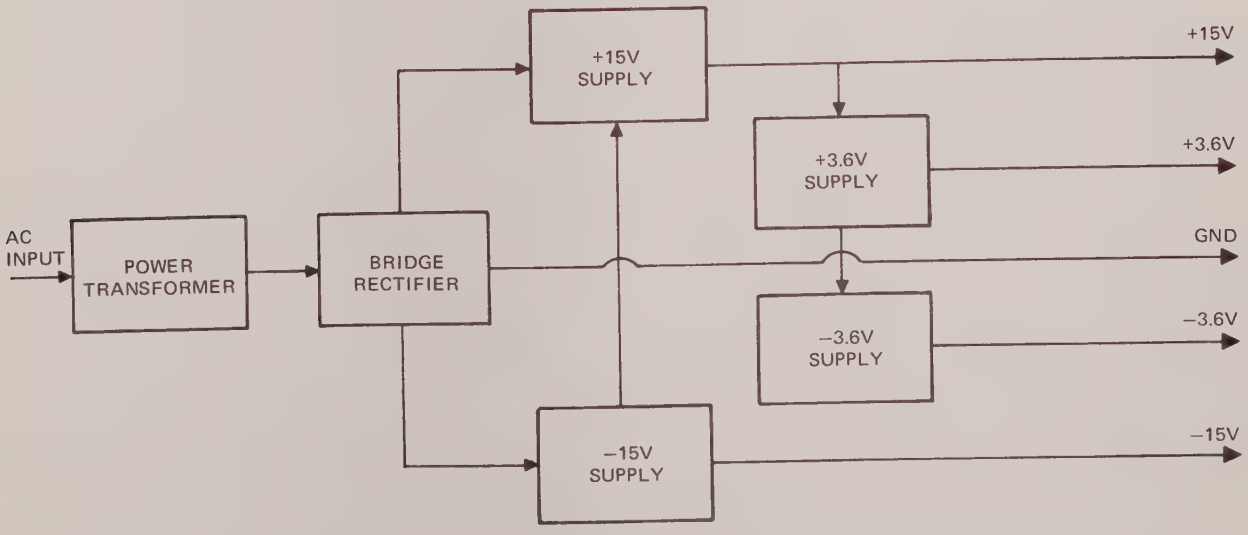


Figure 3-5. DC Power Supplies, Functional Block Diagram

conduct, starting to short the base of Q2 to the +15 volt output. In this condition, the output can be shorted indefinitely at a lower than maximum power dissipation of Q1. When the overload condition is removed from the +15 V output, the base of Q2 starts to rise. As the emitter of Q1 rises toward +15 volts, Voltage Divider R3-R4 has more effect on the base of Q3 and eventually turns Q3 off completely. When Q3 turns off, the normal condition is restored. Q10 with R28, R29, and R30, form a foldback current limiter for the −15 volt regulator.

The +3.6 volt supply is provided by Q5 and Q6 operating as a Comparator Differential Amplifier controlling the Series Pass transistor Q7. The error signal is obtained from the wiper of R20, in a Voltage Divider comprised of R18, R20, and R21 between +3.6 volts and −15 volts (the −15 volts here acts as a reference voltage) and R2 is used as the +3.6 volt adjustment.

The −3.6 volt supply is provided by IC2 operating as a Unity Gain Operational Amplifier.

3.3 SUPPLEMENTAL CIRCUITS

There are no unique or supplemental circuits within the Model 740 to be separately described as "Supplemental Circuits". The preceding circuit descriptions adequately describe the complete circuitry of the Model 740 to the degree required by a competent technician.

SECTION 4
MAINTENANCE

4.1 ACCESS INSTRUCTIONS

Removal of the dust cover affords quick access to the majority of components within the unit. However, it may be necessary to remove the Zero Crossing Board in order to gain access to those components not exposed by removing the dust cover. Instructions for both are given below.

4.1.1 Removing the Dust Cover

To remove the dust cover (case) from the Model 740 Phase Meter, the following procedure should be followed.

1. Unplug the power cord.
2. Unscrew two captive screws on rear panel.
3. Remove rear casting.
4. Set instrument face down on soft surface and, watching clearance between bottom board and cover, lift cover off slowly.
5. Reverse this procedure when replacing dust cover. Tighten the captive screws only finger-tight.

4.1.2 Removing the Zero Crossing Board

To remove the Zero Crossing Board from the Model 740 Phase Meter, proceed as follows:

1. Set instrument on its side and disconnect the pins of the two sets of three input connectors. These are located near the front of the bottom board.
2. Remove the three bottom screws on both sides of the instrument holding the Zero Crossing Board to the side plates.
3. Slide Zero Crossing Board back until printed circuit board clears the front panel.
4. Swing the Zero Crossing Board out from the front and replace the screws at the rear of the board. This allows the user to get at both sides of the Zero Crossing Board while the instrument is operating.

NOTE

The inputs are now available at the pins on the front of the Zero Crossing Board.

5. To replace the Zero Crossing Board, reverse the above procedure. When reconnecting the input pins, use the following diagram.

Component Side of Zero Crossing Board

4.2 CALIBRATION INSTRUCTIONS

This paragraph provides complete sequential calibration instructions for the Model 740 Phase Meter. The instructions are concise and are written for the experienced electronics technician or field engineer having a working knowledge of this type of instrumentation.

WAVETEK maintains a factory repair department for those customers not possessing the necessary test equipment or personnel to maintain this type of instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached. This will hasten turnaround time.

Test point and control locations necessary for calibration are given within this section unless a foldout illustration is required. In the latter instance, the foldout illustration will be found at the rear of the manual.

4.2.1 Recommended Test Equipment

The following test equipment (or equivalent) is recommended for this calibration procedure.

VCG/VCA Generator	Wavetek Model 136
Voltmeter	1 mV Resolution
Phase Angle Generator	Dytronics Model 410
Oscilloscope	Tektronix Model 454
Flat-bladed screwdriver	1/8-inch

4.2.2 Preliminary Procedures

Before attempting to recalibrate this instrument, the user should read and understand the entire calibration proce-

dure. The four major segments of this procedure should be performed in the sequence given, as should the steps within each segment.

1. Connect the Model 740 Phase Meter in the test set up illustrated in Figure 4-1[A].
2. Set POWER switch to ON, set METER SENSITIVITY selector for ±180° and allow a 30-minute warmup period before attempting to calibrate this instrument.

4.2.3 Full Scale Calibration Procedure

3. With equipment connected as shown in Figure 4-1[A]; hold CALIBRATE switch up (+180.0) and adjust +180.0 ADJ R79 for −1.800 volts plus or minus 0.3 mV on dc output.
4. Hold CALIBRATE switch down (−180.0) and adjust −180.0 ADJ R81 for +1.800 volts plus or minus 0.3 mV on dc output.

4.2.4 Logic Board Calibration Procedure

NOTE

Perform steps 5 through 13 only if steps 3 and 4 do not meet specifications.

5. Remove the dust cover and the display unit from the Model 740 Phase Meter following the procedures outlined in paragraph 4.1.1.

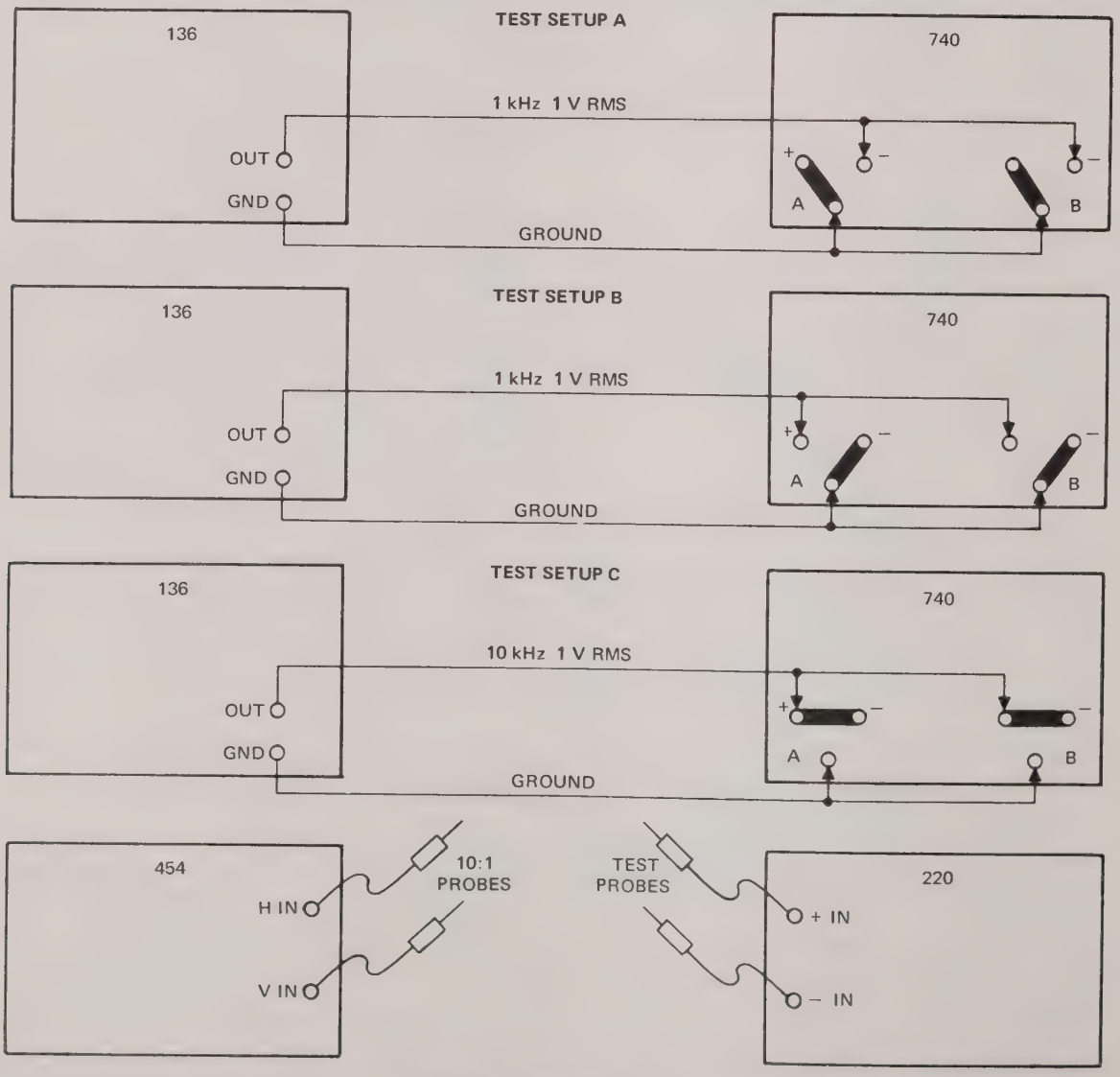


Figure 4-1. Calibration Set-Up

6. Connect the voltmeter to the +3.6 V supply at test points TP1 and TP2 (Figure 4-2).
7. Set POWER switch to ON and allow a 30-minute warmup period before attempting to calibrate this instrument.
8. Set METER SENSITIVITY selector for ±180°, and OFFSET switch to OUT. Ignore the front panel meter reading.
9. Adjust −15 V ADJ R36 while monitoring the +3.6 V supply, and set to +3.600 V ±2 mV.
10. Connect the voltmeter to the OUTPUT −10mV/DEG dual-banana plugs.
11. Hold CALIBRATE switch up (+180.0) and adjust +180.0 ADJ R81 for +1.800 V ±.3 mV on the voltmeter.
12. Hold CALIBRATE switch down (−180.0) and adjust −180.0 ADJ R79 for −1.800 V ±.3 mV on the voltmeter.
13. Repeat steps 11 and 12 and, if readings within ±.3 mV cannot be obtained, performs steps 1 through 4 and repeat steps 8 through 12. If proper indications still cannot be obtained, refer to the trouble shooting instructions given in Section 4 of this manual.

4.2.5 Zero-Crossing Mid-Frequency Procedure

14. Turn power on and short out resistors R1, R5, R92, and R96 with short jumper wire or clip leads.
15. Connect a 1 kHz sine wave, 10 mV rms (28 mV p-p), into each input (Figure 4-1[A]).
16. Check 10:1 oscilloscope probe for dc zero, by putting scope probe on GND banana plug and center trace on horizontal centerline of CRT. Set scope gain to 10 mV/centimeter, and sweep speed to 0.1 ms/centimeter.
17. Connect the scope probe to Channel A test point TP2 (Figure 4-3) of the Zero Crossing Board. The oscilloscope should display a waveform similar to the one shown in Figure 4-4[B].
18. Adjust DC BALANCE ADJ R28 so that V1 is equal to V2 (±10 mV).

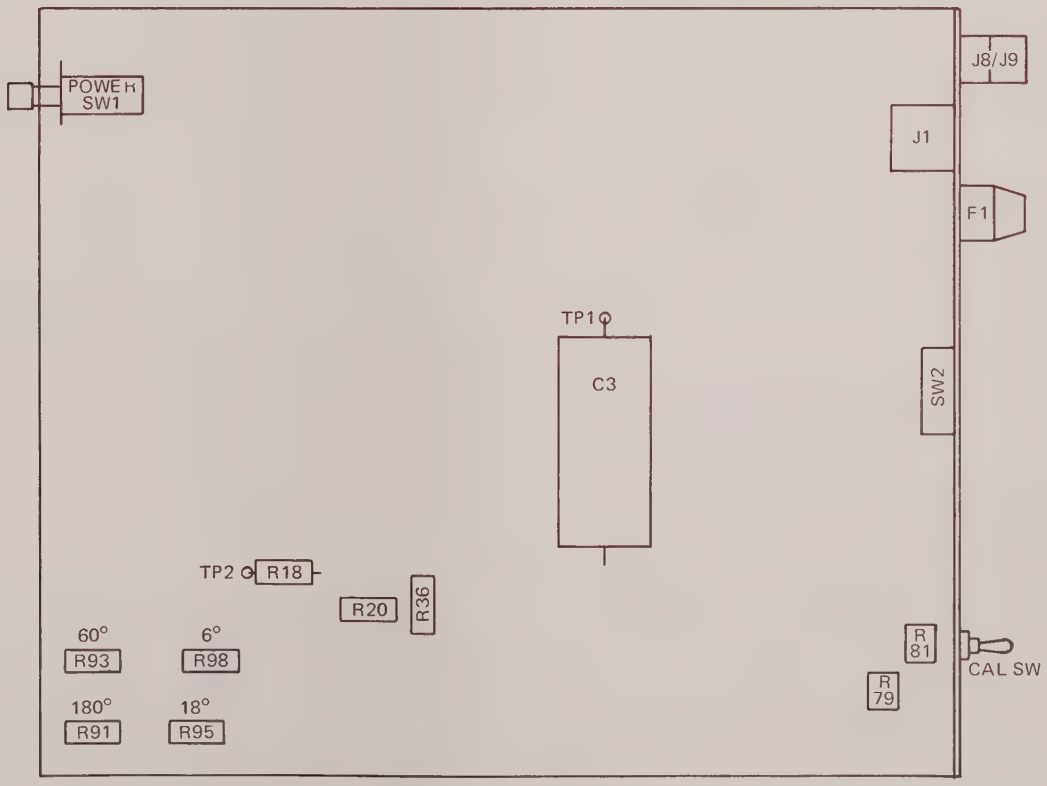


Figure 4-2. Logic Board Adjustment Locations.

19. Adjust CHOPPER BALANCE ADJ R64 so that t_1 is equal to t_2 (±1 μS).
20. Alternately perform steps 18 and 19 until the closest to optimum results are obtained.
21. Adjust TD ADJ R63 until top of tunnel diode trigger is at zero volts dc (±1 mV) as shown in Figure 4-4[B].
22. Connect scope probe to test point TP5, adjust DC BALANCE ADJ R119, CHOPPER BALANCE R155, and TD ADJUST R154 and perform steps 18 through 21 for Channel B. Recheck oscilloscope for dc drift by connecting the scope probe to the phase meter ground and adjusting scope controls to reposition trace on horizontal center line.
23. If steps 14 through 22 have been followed correctly, the dc output should equal one half of plus and minus full scale (CALIBRATE switch up and down readings). This reading is called "out of case zero" in the rest of the manual.

Examples:

Calibrate "Up"	Calibrate "Down"	"Out of Case Zero"
+180.0	−180.0	0.0 (±.1°)
+180.2	−179.8	+0.2 (±.1°)
+180.2	−179.4	+0.4 (±.2°)

N O T I C E

Do not be alarmed if the full scale values are not precise, the instrument is out of the case and will return to proper readings when case is replaced. It is important, however, that the "out of case zero" be displaced equally from the range extremes.

DO NOT READJUST
FULL SCALE VALUES AT THIS POINT

If "out of case zero" is not equally displaced repeat steps 14 through 22 and step 24 below. Go on to the Zero Crossing High Frequency Procedure; three or four tenths of a degree error could be caused by high frequency misalignment.

N O T I C E

24. Increase the input signal amplitude to both channels to 1 V rms (2.8 V p-p). If reading changes more than ±0.1°, adjust PK-PK ADJ R21 and R112 for accurate time symmetry at test points 2 and 5, as shown in Figure 4-4[C].

4.2.6 Zero-Crossing High-Frequency Procedure

25. Short out resistors R1, R5, R92, and R96 with short jumper wire or clip leads and remove all scope probes.
26. Apply a 10 mV rms sine wave, 80 kHz, into both channels, using the test configuration shown in Figure 4-1[A].
27. Adjust C22 until meter readout is equally displaced from range extremes for "out of case zero" (±0.2).
28. Increase input amplitude to 100 mV rms, increase input frequency to 800 kHz, and adjust C10 until the meter readout equals "out of case zero" (±.4°).
29. Since steps 27 and 28 interact, they must be alternately performed until both readings, when going from one condition to the other, are within limits. Recheck steps 17 through 22 and, if necessary, readjust controls for proper indications.
30. Apply a 1 mV rms sine wave to both inputs, using the configuration shown in Figure 4-1[A] and, while watching the meter readout, vary the frequency from 1 kHz to 10 kHz. Record the reading at 1 kHz and the reading at 10 kHz. Determine the difference between the two readings, taking into account the polarities indicated, and record this as the "error span".

Examples:

1 kHz Readings	10 kHz Readings	Error Span
−000.1	+001.0	1.2°
+000.2	+001.1	.9°
−000.2	−000.8	.6

31. Set input frequency back to 1 kHz at 1 mV rms and equally adjust Channel A Tunnel Diode ADJ R63 and Channel B Tunnel Diode ADJ R154 so that the meter indicates one-third of the Error Span with a minus sign. (This would be 0.4° in the first example shown in step 30.)
32. Set input frequency to 10 kHz at 1 mV rms and meter should indicate two-thirds of the Error Span. If the Error Span is not distributed one-third and two-thirds at 1 kHz and 10 kHz respectively, repeat steps 30 and 31.

4.2.6.1 COMMON MODE REJECTION CALIBRATION

33. Apply a 10 kHz, 10 mV rms, sine wave to both inputs as shown in Figure 4-1[C]; with R1, R5, R92, and R96 shorted out.
34. Connect scope probe to test point TP2, and alternately adjust R187 and C11 for minimum signal. Increase input to 1 V rms and adjust for double input frequency at TP2.
35. Connect scope probe to test point TP5, and alternately adjust R190 and C139 for minimum signal with 10 mV

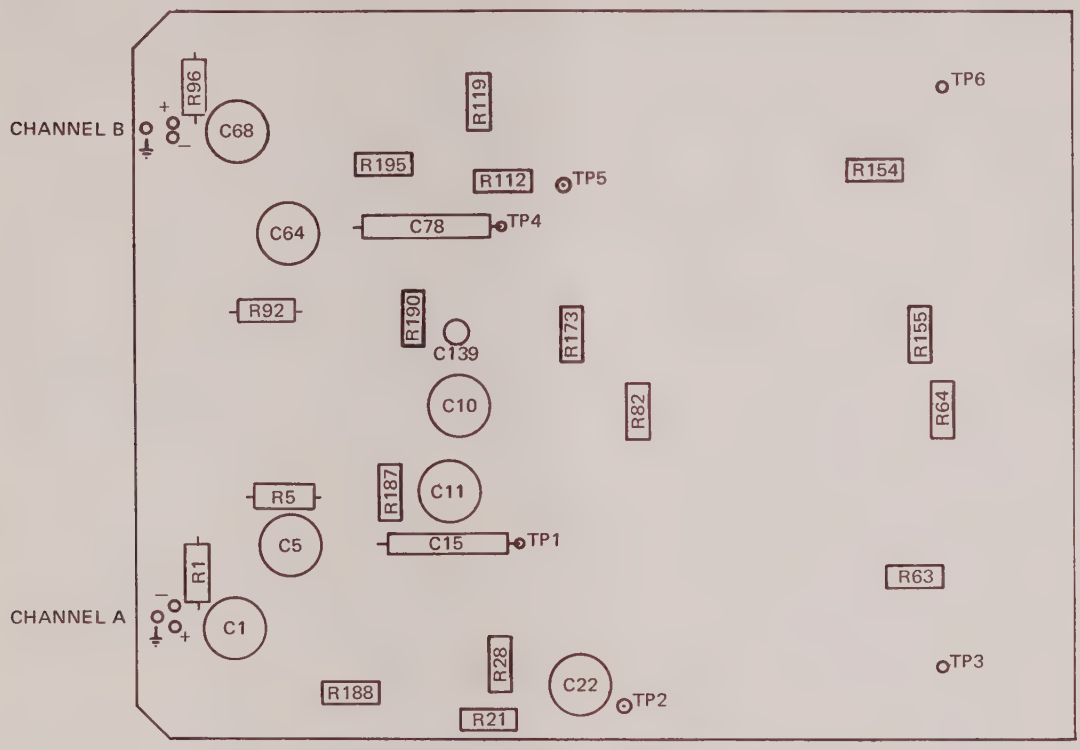


Figure 4-3. Zero Crossing Board Adjustment Locations

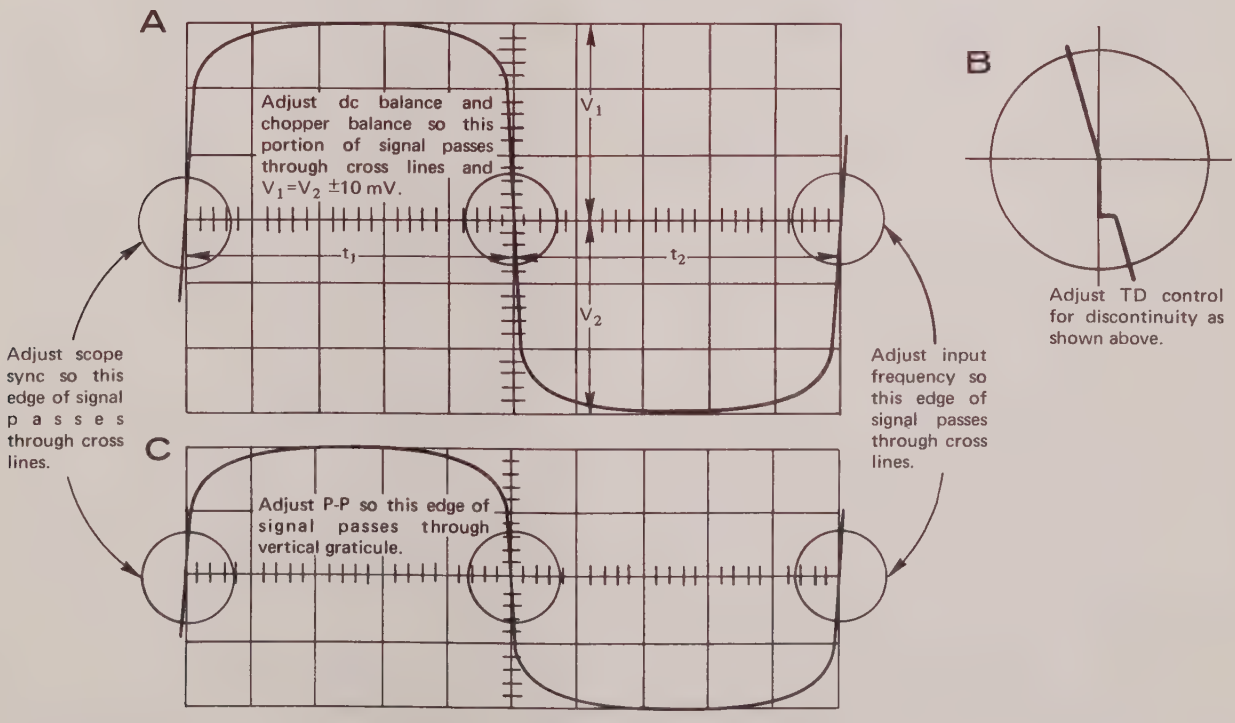

A
Adjust dc balance and chopper balance so this portion of signal passes through cross lines and $V_1=V_2$ ±10 mV.
V_1
V_2
t_1
t_2
Adjust scope sync so this edge of signal passes through cross lines.
Adjust input frequency so this edge of signal passes through cross lines.
B
Adjust TD control for discontinuity as shown above.
C
Adjust P-P so this edge of signal passes through vertical graticule.

Figure 4-4. Oscilloscope Calibration Displays

input. Increase amplitude to 1 V rms and adjust for input frequency doubling at TP5.

NOTE

Minimum signal refers to minimum amplitude of frequency applied to input.

4.2.6.2 ATTENUATOR FREQUENCY ADJUSTMENT

36. Remove jumpers from R1, R5, R92, and R96 and apply a 1 kHz, 7 V rms sine wave to the positive input terminals as shown in Figure 4-1[B]. Connect the probes of a dual channel scope, with lissajous capability, between the plus input terminal and test point TP1 of Channel A.
37. While varying the input frequency from 1 kHz to 10 kHz, adjust C1 for a closed lissajous.

NOTE

Make sure the oscilloscope probes are properly compensated for lissajous operation. Check each probe with the scope calibrate signal, then connect both probes to the same signal and vary the frequency from 10 Hz to 1 MHz and make final adjustment for closed lissajous.

38. Connect the scope probes from TP1 to TP4 of Channel B. Adjust C64 for a closed lissajous. The meter should now read within ±.2° of reading obtained with 100 Hz input (switch to 100 Hz without changing amplitude and check). If it doesn't, repeat steps 36 and 37 until the indication is within this limit.

4.2.6.3 ATTENUATOR COMMON MODE REJECTION ADJUSTMENT

39. With the jumper removed from R1, R5, R92, and R96 apply a 7 V rms 25 Hz sine wave to both inputs as shown in Figure 4-1[C].
40. Connect scope probe to test point TP2, and adjust R188 for minimum signal.
41. Increase input frequency to 25 kHz, and adjust C5 for minimum amplitude at TP2.
42. Connect scope probe to test point TP5, decrease input frequency to 25 Hz, and adjust R195 for minimum signal.
43. Increase input frequency to 25 kHz, and adjust C68 for minimum amplitude at TP5.
44. Repeat steps 39 through 43 if required.
45. Replace the dust cover by following the instructions in paragraph 4.1.1; apply POWER, and allow 20 minutes for the unit to reach a stable operating temperature.
46. Check plus and minus full scale calibration applying the same sine wave, 1 kHz at 1 V rms, to both inputs as shown in Figure 4-1[A].

4.2.6.4 HIGH AND LOW AMPLITUDE ADJUSTMENT

47. With jumper removed from R1, R5, R92, and R96 apply a 1 kHz, 5 V rms, sine wave to INPUT A. Apply a 50 mV sine wave to INPUT B.
48. Reading should be less than ±1.5°. If not, adjust TUNNEL DIODE ADJ R154 until reading is less than 1.0°.
49. Apply a 1 kHz, 5 V rms, sine wave to INPUT B and apply a 50 mV sine wave to INPUT A.
50. If reading is not more than 1.5° adjust TUNNEL DIODE ADJ R63 for less than 1.0°.
51. Apply a 1 kHz, 50 mV rms, sine wave to INPUT A and INPUT B. Reading should be less than 1.5° (typically ±0.5°) repeat steps 47 through 50 until the meter is within this limit.

4.2.6.5 METER CALIBRATION

NOTE

The meter calibration can only be as accurate as the test equipment used in calibration; therefore, a ±0.1° phase angle generator is recommended.

52. With power off, mechanically zero meter.
53. Connect 740 to a phase angle generator with ±0.1° or better accuracy.
54. Turn 740 power on and let stabilize for 20 minutes.
55. Place the OFFSET switch in OUT position.
56. Select ±180° METER SENSITIVITY. Set phase source to 180° at 1 kHz, 1 V rms into both inputs, and adjust 180° meter ADJ R91 for full scale reading. See figure 4-2. Interchange inputs (exchange Channel A's input with Channel B's input), note error on meter, and adjust out ½ of error with R91.
57. Select ±60° METER SENSITIVITY. Set phase source to 60° at 1 kHz, 1 V rms into both inputs and adjust 60° meter ADJ R93 for full scale reading. Interchange inputs, note error on meter, and adjust out ½ of error with R93.
58. Select ±18° METER SENSITIVITY. Set phase source to 18° at 1 kHz, 1 V rms into both inputs and adjust 18° meter ADJ R95 for full scale reading. Interchange inputs, note error on meter, and adjust out ½ of error with R95.
59. Select ±6° METER SENSITIVITY. Set phase source to 6° at 1 kHz, 1 V rms into both inputs and adjust 6° meter ADJ R98 for full scale reading. Interchange inputs, note error on meter, and adjust out ½ of error with R98.

4.3 CORRECTIVE MAINTENANCE

If the Model 740 Phase Meter appears to be operating abnormally, and an investigation of input/output connec-

tions, as well as a calibration check, do not cure the problem; follow the trouble-shooting procedure outlined below.

Trouble	Check
1. Meter jumping around when no input signal is applied.	Normal operation, the high sensitivity of the input picks up external 60 Hz noise.
2. Meter jumping occasionally with low input amplitude and/or frequency.	Noise spikes are riding on input signal or signal-to-noise ratio is too high. Put 0.1 μF capacitors, or matched filters, across inputs.
3. Meter jumping randomly with input signal applied.	a. Check that phase angle is not within 2° of +180° or −180°. If it is, reverse input connection of INPUT A and subtract 180° from reading. This places reading away from ambiguity. b. Reduce ground loops, and use differential inputs isolating grounds.
4. Erroneous phase reading.	a. Check rms voltage of inputs. Overdrive causes phase errors. b. Quick check CALIBRATE limits. c. If "a" and "b" do not help, apply same input to both channels, if reading is within specifications. recalibrate Zero Crossing board.
5. Display not lighted when POWER is set to ON.	Check fuse. Check ±15 V, and ±3.6 V power supplies.
6. Display locked on maximum or minimum full scale regardless of inputs.	a. If locked on maximum, check Channel A Zero Crossing for no output. b. If locked on minimum, check Channel B Zero Crossing for no output. c. If not "a" or "b" check IC4 on the Logic and Power Supply board.
7. Input loading circuit being measured due to low input impedance.	Input FET has been damaged. Replace with MPF104 or 2N5458 or equivalent.

If the instrument is not operating properly, and the above steps do not solve the problem, recalibrate the instrument as described in paragraph 4.2. If recalibration does not solve the problem, follow the procedure outlined below.

1. First check all power supplies for proper operation. If any are malfunctioning, refer to the Circuit Description as well as the schematic when trouble shooting the supply.
2. With 1 kHz 1 V rms sine waves applied to both inputs, look at Zero Crossing test points TP3 and TP6. If 3 V pulses at 1 kHz are not observed, read Circuit Description and refer to the schematic for trouble shooting.
3. If the proper pulses are seen in step 2 above, look at the junction of R65, R66, and R68. This point should show a waveform like that pictured below.

INPUT 0 V rms, 1 kHz, 0° RANGE set to −180°/+180°

SECTION 5
NOTES AND ADDENDUMS

5.1 ADDENDUMS

WAVETEK'S product improvement program incorporates the latest electronic developments into these instruments as rapidly as development and testing permit. Due to the time required to document and print these instruction manuals, it is not always possible to include the change information in the final printing. When this occurs, change pages or addendum sheets are prepared for insertion immediately behind the title page. If no such pages exist, the manual is correct as printed.

5.2 NOTES

The space below may be used to record pertinent data relating to a specific unit, or general information helpful to user. When minor "special" features are requested in the purchase order, WAVETEK will summarize these features below.

SECTION 6
PARTS AND SCHEMATICS

6.1 DRAWINGS

The following assembly drawings (with parts lists) and schematics are in the arrangement shown below.

6.2 ORDERING PARTS

When ordering spare parts, please specify part number, circuit reference, board, serial number of unit and, if applicable, the function performed.

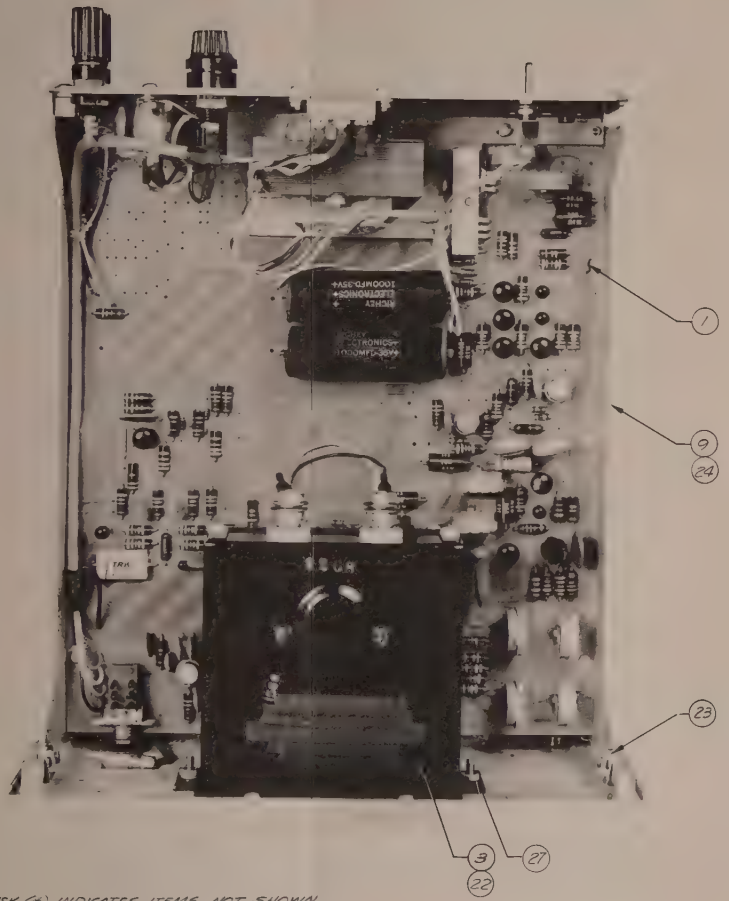
6.3 ADDENDA

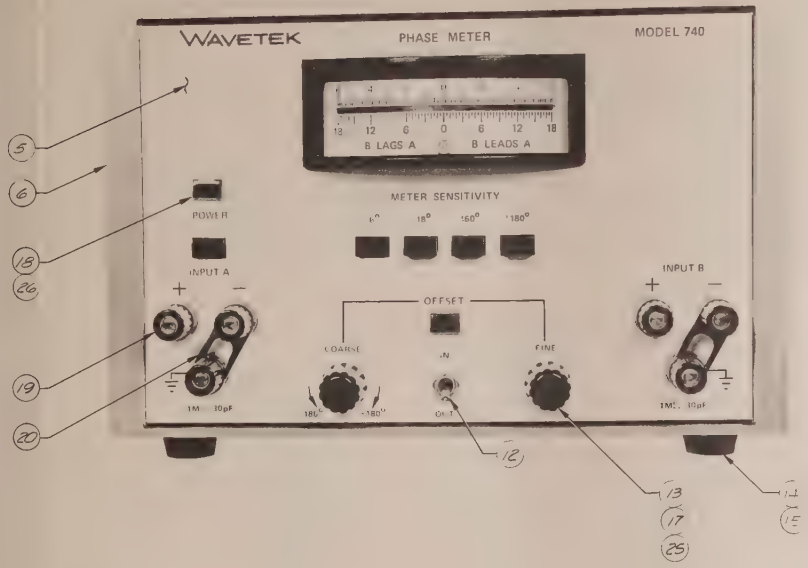
Under Wavetek's product improvement program, the latest electronic designs and circuits are incorporated into each Wavetek instrument as quickly as development and testing permit. Because of the time needed to compose and print instruction manuals, it is not always possible to include the most recent changes in the initial printing. Whenever this occurs, addendum pages are prepared to summarize the changes made and are inserted immediately inside the rear cover. If no such pages exist, the manual is correct as printed.

CROSS REFERENCE FOR DRAWING NUMBERS

Drawings	Old Number	New Number
Chassis Assy	740-000	0102-00-0319
Chassis Schematic	740-200	0004-00-0060
Chassis Parts List	*	1101-00-0060
Zero Crossing Assy	740-011	0101-00-0134
Zero Crossing Schematic	740-211	0103-00-0134
Zero Crossing Parts List	*	1100-00-0134
Power Supply & Logic Assy	740-010	0101-00-0133
Power Supply & Logic Schematic	740-210	0103-00-0133
Power Supply & Logic Parts List	*	1100-00-0133
Bracket Assy	740-001	0102-00-0334
Bracket Parts List	*	1101-00-0076

*Same as assembly number





NOTE: ASTERISK (*) INDICATES ITEMS NOT SHOWN

rev	description	by	date	appd
F	ECN 934			
E	ECN 408			
D	ECN 4[illegible]			
C	ECN 4[illegible]			
B	ECN 4[illegible]			
A	ECN 294			

tolerance unless otherwise specified	XXX ± 0.0 XX ± 030
scale	1 : 1
material	N/A
finish	N/A
WAVETEK	San Diego
by	Scott
date	1-10
title	CHASSIS ASSY
model no	740
dwg no	0102-00-1319
rev	E

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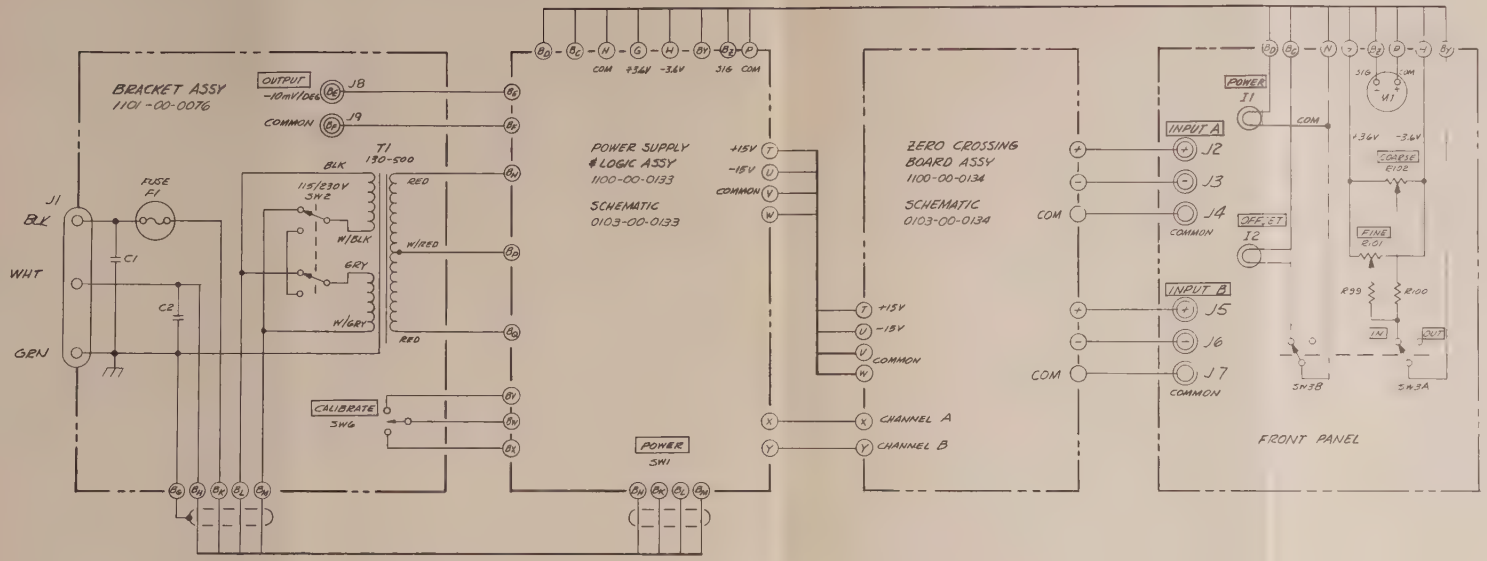

NOTES: UNLESS OTHERWISE SPECIFIED
1. LETTERS ARE INTERCONNECTION POINTS.

B	441	EC		
A	ECN	NG		
rev	ECN	by	title	ICC

tolerance unless otherwise specified: XXX ± .010, XX ± .030

WAVETEK san diego

scale NA | by MAST | date 9 DEC 69 | approved

material: NA

title: SCHEMATIC, CHASSIS

finish: NA

model no. 740 | dwg no. 0004-00-0060 | rev 5

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REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	DWG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	SCHEMATIC,INSTRUMENT	0000-00-0060	WVTK	0000-00-0060	1
NONE	ASSY DRWG,CHASSIS	0102-00-0319	WVTK	0102-00-0319	1
NONE	ASSY DRWG,BRKT	0102-00-0334	WVTK	0102-00-0334	1
1	COVER ASSY	130-353-1	WVTK	1201-00-0017	1
2	RAIL,SIDE	130-304	WVTK	1400-00-1073	2
3	CASTING,FRONT FROM:1400-00-4711	740-300	WVTK	1400-00-4729	1
4	CASTING,REAR FROM:1400-00-4711	740-301	WVTK	1400-00-4739	1
5	PANEL,FT	740-302	WVTK	1400-00-4760	1
6	PANEL,REAR	740-303	WVTK	1400-00-4770	1
7	SHIELD	740-309	WVTK	1400-00-4813	1
8	BINDING POST	DF-21-BC	SUPER	2100-01-0001	6
9	TERM,LUGS LUG	1418-10	SMITH	2100-00-0007	2
10	SHORTING LINK	938-L	GENRD	2100-00-0020	2
11	KNOB	020-322	ELMA	2400-01-0002	2
12	KNOB CAP	040-302	ELMA	2400-01-0004	2
13	RED LENS	BNG-51	ALCO	2400-02-0001	2
14	LAMP	CM7-7876	CHMIN	2400-02-0013	2

WAVETEK PARTS LIST | TITLE STD CHASSIS | ASSEMBLY NO. 1101-00-0060 PAGE: 1 | REV G

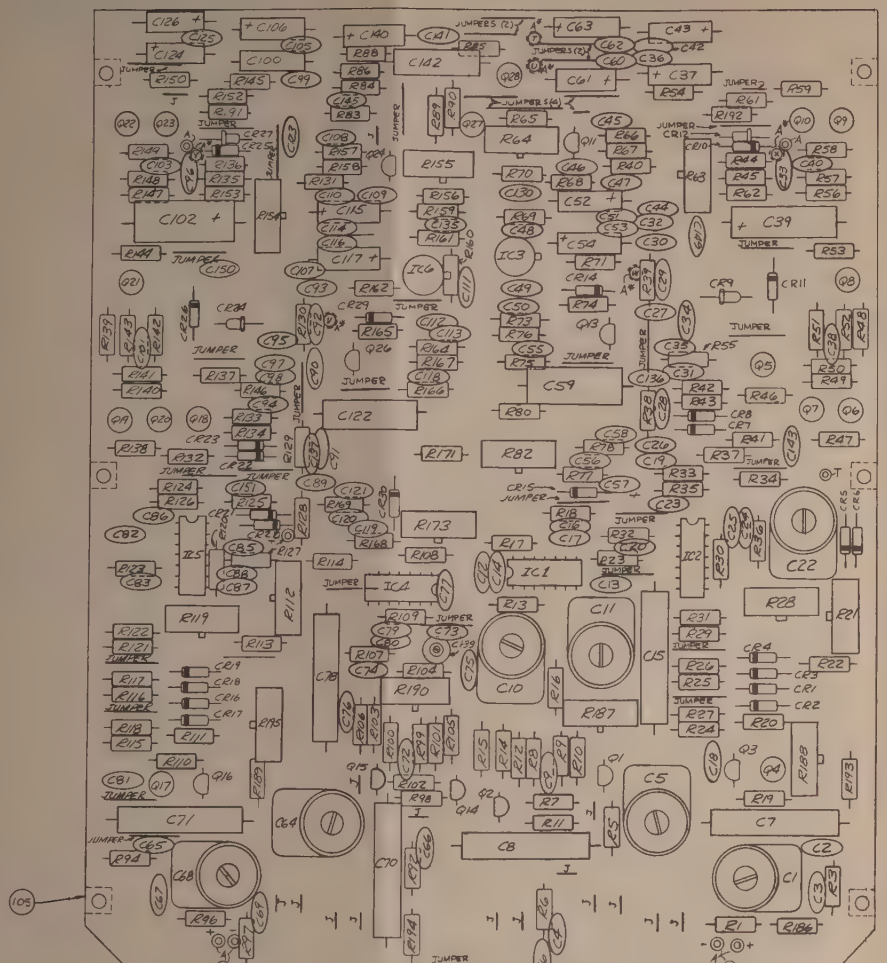
REFERENCE DESIGNATORS	PART DESCRIPTION	DWG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
15	METER	740-503	WVTK	2400-00-0002	1
16	SPEEDNUT,TYPE"U"	C8091-632-8	TINN	2800-09-0004	4
17	PRESS BOLT	P8-6-32-BM-10	ROSAN	2800-09-0009	2
18	PLUG BUTTON	PC67291	UNCAR	2800-09-0010	2
19	FAST,CHASSIS	1591-811	USECO	2800-09-0021	16
20	CAPTIVE SCREW	CA1376-10-3-9	FAIDR	2800-23-0001	2
21	POT,CONT,1K	UM-5906	CTS	4400-01-0202	2
R99	RES,C,1/2W,10%,560K	RC20GF-564	STKPL	4700-25-5603	1
R100	RES,MF,1/8W,1%,18.2K	RN55D-1822F	TRW	4701-03-1822	1
24	SWITCH,TOGGLE	7201 PDZW	C&K	5106-00-0010	1
25	PWR CORD	17258-B	BELDN	6001-80-0003	1

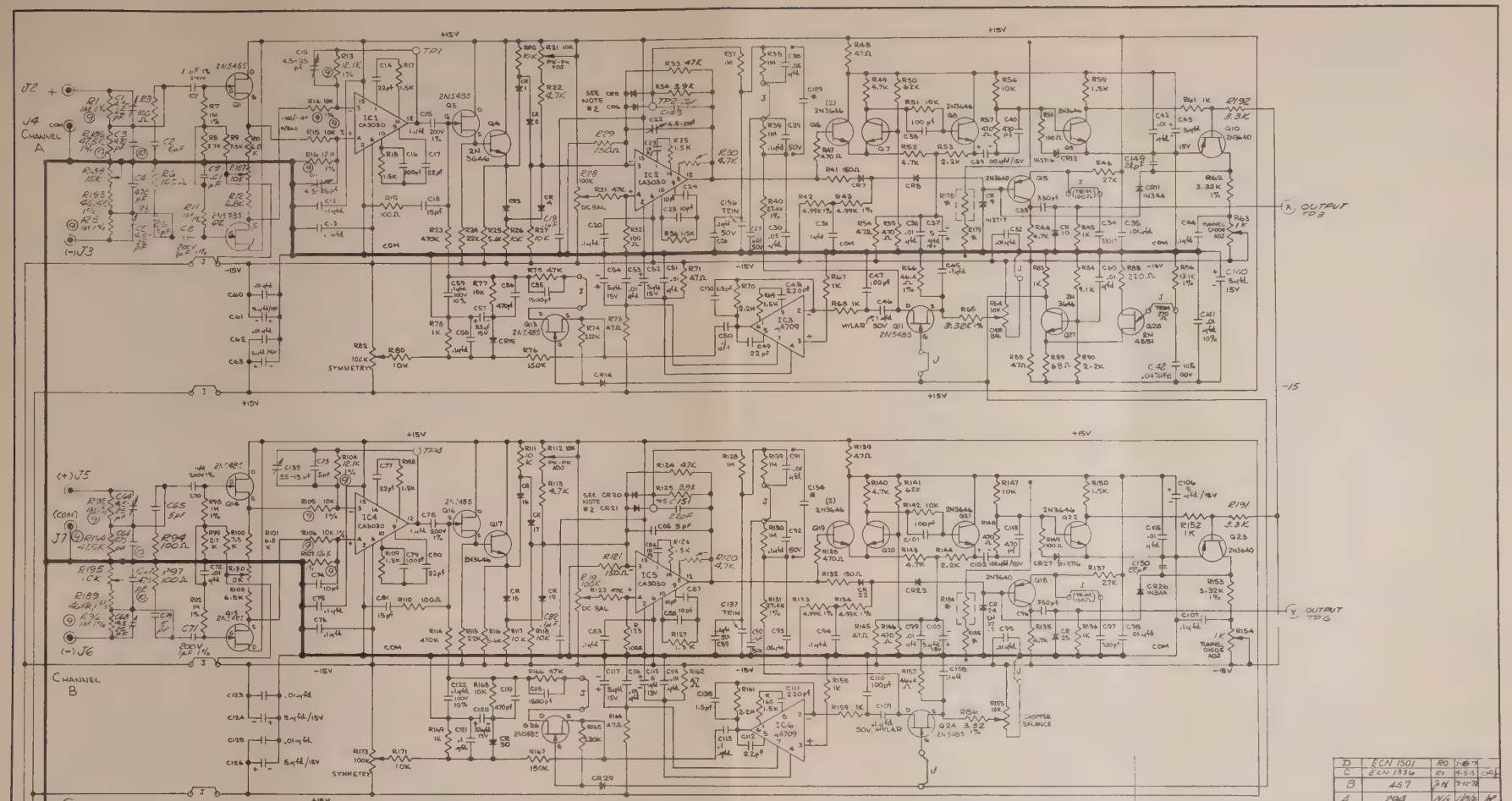
WAVETEK PARTS LIST | TITLE STD CHASSIS | ASSEMBLY NO. 1101-00-0060 PAGE: 2 | REV G

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE CHASSIS
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030		MODEL NO. 740 DWG NO. 1101-00-0060 REV G
	DO NOT SCALE DWG		CUSTOMER DRAWING 23338 SHEET 1 OF 1
	SCALE		

CHANNEL B

CHANNEL A





NOTES: – UNLESS OTHERWISE SPECIFIED –
1. ALL RESISTORS ½ WATT, 10% CARBON
2. HP 2811 DIODES MATCHED
3. ALL DIODES FD6666
4. # INDICATES PROVISIONAL COMPONENTS (R174 THRU R185, R72 & R163 & C127, C128, C129, C132, C133 & C134)
5. R175, 176, 177, 181, 182 & 183 ARE 3.9Ω.
6. C127, 128, 129, 132, & 133 ARE 100 μfd.
7. J INDICATES JUMPER
8. R72 & R163 ARE 1.5K
9. (N) GOOD MATCHED SET
10. (M) MATCHED SILVER MICA SET
11. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.
12. Q1, Q2, Q14, Q15 ARE SELECTED TO SPEC NUMBER 4998-00-0006; Q3 & Q16 ARE SELECTED TO SPEC NUMBER 4998-00-0007.

LAST COMP DES. USED
CR30 C151
R195 Q28
TP6 IC6

rev	description	by	date	appd
D	ECN 1501	RO	11-8-71	
C	ECN 1336	RO	4-5-5	
B	457	JH	7-11-70	
A	294	NG	1/8/70	

tolerance unless otherwise specified: XXX ± .010, XX ± .030
scale N/A
material N/A
finish N/A

WAVETEK san diego, calif
dyl. ADAMSON date 7/A/69 appd

title: SCHEMATIC, ZERO CROSSING BOARD

model no. 740 | dwg no 0103-00-0134 | rev D

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REV	ECN	BY	DATE	APP

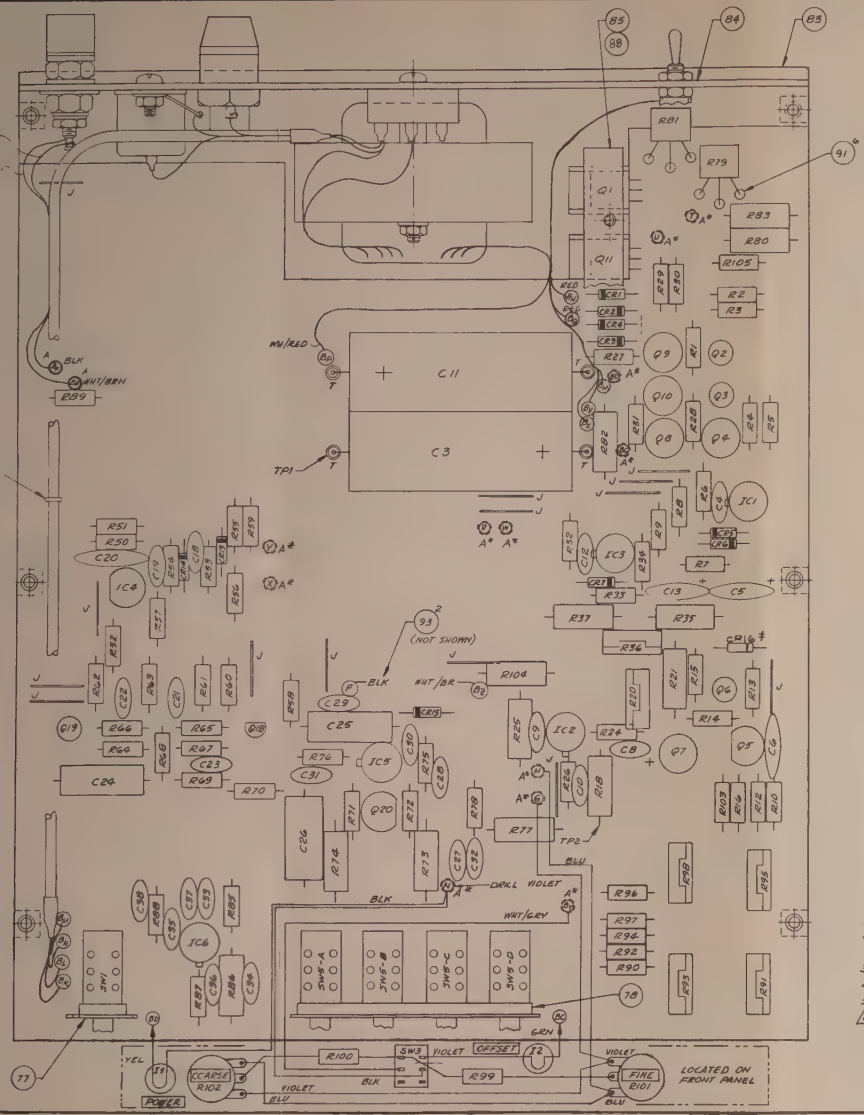
REFERENCE DESIGNATORS	PART DESCRIPTION	OMIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	TERM	201081	JSECC	2100-05-0011	2
NONE	CONN	60598-8	AMP	2100-05-0017	16
NONE	MEM,MALE	61182-2	AMP	2180-05-0020	14
R134 R83	POT,TRIM,1K	V14A1K	MECH	4600-01-0209	2
R145 R84	POT,TRIM,10K	FR-103P	AB	4600-01-0301	2
R112 R147 R188 R190 R145 R81	POT,TRIM,10K	91A810K	MECH	4600-01-0315	6
R114 R173 R69 R82	POT,TRIM,100K	V14A-103-	BECK	4600-01-0402	4
R181 R70	RES,C,1/2W,10%,2.2M	RC20GF225J	STACK	0700-25-2206	2
R110 R123 R149 R19 R5 R52 R58 R6 R94 R97	RES,MF,1/8W,1%,100	RN55D-1000F	TWR	4701-03-1000	10
R136 R152 R158 R159 R169 R85 R61 R67 R68 R78 R83	RES,MF,1/8W,1%,1K	RN55D-1001F	TWR	4701-03-1001	11
R111 R117 R118 R142 R147 R168 R171 R29 R26 R27 R51 R56 R77 R80	RES,MF,1/8W,1%,10K	RN55D-1002F	TWR	4701-03-1002	14
R121 R132 R29 R41	RES,MF,1/8W,1%,150	RN55D-1500F	TWR	4701-03-1500	4
R106 R109 R126 R127 R150 R160 R17 R18 R35	RES,MF,1/8W,1%,1.5K	RN55D-1501F	TWR	4701-03-1501	12
R36 R59 R69	RES,MF,1/8W,1%,150K	RN55D-1503F	TWR	4701-03-1503	2
R167 R76	RES,MF,1/8W,1%,19.1K	RN55D-1912F	TWR	4701-03-1912	1
R115 R24	RES,MF,1/8W,1%,21.5K	RN55D-2152F	TWR	4701-03-2152	2
R85	RES,MF,1/8W,1%,221	RN55D-2210F	TWR	4701-03-2210	1
R144 R53 R90	RES,MF,1/8W,1%,2.21K	RN55D-2211F	TWR	4701-03-2211	3
R165 R70	RES,MF,1/8W,1%,221K	RN55D-2213F	TWR	4701-03-2213	2
R131 R137 R40 R46	RES,MF,1/8W,1%,27.4K	RN55D-2742F	TWR	4701-03-2742	4
R8 R49	RES,MF,1/8W,1%,2.87K	RN55D-2871F	TWR	4701-03-2871	2
R153 R155 R191 R192 R62 R65	RES,MF,1/8W,1%,3.32K	RN55D-3321F	TWR	4701-03-3321	6
R125 R30	RES,MF,1/8W,1%,3.92K	RN55D-3921F	TWR	4701-03-3921	2
R138 R166 R169 R87 R55 R57	RES,MF,1/8W,1%,464	RN55D-4640F	TWR	4701-03-4640	6
R189 R183	RES,MF,1/8W,1%,4.64K	RN55D-4642F	TWR	4701-03-4642	2
R139 R145 R157 R162 R164 R49 R56 R66 R71 R73 R88	RES,MF,1/8W,1%,46.4	RN55D-46R4F	TWR	4701-03-46R4	11
R113 R120 R135 R140 R143 R22 R30 R40 R49	RES,MF,1/8W,1%,8.75K	RN55D-8751F	TWR	4701-03-8751	10
R92					
CR24 CR9	DIODE	1N3717	GE	4802-01-3717	2
CR11 CR26	DIODE	1N34	FAIW	4804-01-0034	2
CR1 CR10 CR14 CR15 CR16 CR17 CR18 CR19 CR2 CR22 CR23 CR25 CR24 CR3 CR30 CR4 CR7 CR8	DIODE	FD6666	FAIW	4807-02-0666	18
J28		2N6851	MOT	4901-06-A510	1
Q11 Q13 Q24 Q26	TRANS	2N5486	RCA	4901-05-0450	4
Q1 Q14 Q15 Q2	TRANS,SEL,6=2N5685 QTY1=4901-05-0A50	760-500-17	WAVE	4904-00-0006	1
Q16 Q3	TRANS,M/PW,2N5685 QTY1=4901-05-0A50	760-500-38	WAVE	4904-00-0007	1
IC1 IC2 IC4 IC5	IC,CL 3 SPEC,CA-3030 QTY1=7200-00-0001	760-500-46	WAVE	7200-00-0003	4
IC3 IC6	IC,SPEC,MA-709 QTY1=7200-00-0005	760-500-75	WAVE	7200-00-0005	2

REFERENCE DESIGNATORS	PART DESCRIPTION	OMIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C1 C44 C47 C6	CAP,CER,470PF,1KV	CM-221	CML	1500-02-2111	2
C33 C34	CAP,CER,330PF,1KV	DD-331	CML	1500-03-3111	4
C17 C41 C43	CAP,CER,470PF,1KV	DD-471	CML	1500-04-7111	4
C45	CAP,CER,.05MF,50V	CK-503	CML	1500-05-0300	4
C1 C10 C11 C12 C13 C14 C15 C16 C17 C18 C19 C2 C20 C21 C22 C23 C24 C25 C26 C27 C28 C29 C3 C30 C31 C32 C4 C5 C7 C8 C9	CAP,ELECT,6.5MF,16V	500D655G016AA2	SPRAG	1500-30-5001	13
C36	CAP,ELECT,100MF,16V	500D107G016DC2	SPRAG	1500-31-0101	2
C37 C44	CAP,METAL,.1MF,50V	804-13A104K	CR	1500-81-0406	2
C42 C46	CAP,MYL,.1MF,100V	MYT21	CDE	1500-81-0424	2
C35 C39 C40 C48 C49 C50 C51	CAP,MYL,.1MF,100V	21MA-IEC-1P5F	IRH	1500-81-0504	6
J29	CAP,MYLAR,.047MF,10%	MME-15W7	ICE	1500-84-7334	1
L1	XFMR,1.5CT-10T,.25CW	7S-T-IK-MW 3.5/13MS	TRIAD	1500-91-3000	1
C31 C32 C38 C52 C53 C54 C55 C56	CAP,TANT,6.8MF,35V	503-051-63M	SPRAG	1500-92-5000	7
C27 C47	CAP,TANT,.33MF,6V	196 334X0006JE3	SPRAG	1500-93-3600	2
C3 C4 C45 C6	CAP,SPEC,.47MF/150+47UF,15V,+50-10+100%	7400-470-6A	WAVE	1509-80-0001	1
XU1	ZERO CROSS	760-111	WAVE	1700-00-0130	1

REFERENCE DESIGNATORS	PART DESCRIPTION	OMIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
CR12 CR27	DIODE	1N3716	GE	4802-01-3716	2

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO, CA. 92123
MATERIAL	ENGINEER		TITLE ZERO CROSSING
FINISH WAVETEK PROCESS	RELEASE APPROV		
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030		MODEL NO 740
	DO NOT SCALE DWG		DWG NO 1100-00-0134 REV H
	SCALE		SHEET 1 OF 1



NOTES: UNLESS OTHERWISE SPECIFIED
1. T INDICATES TERMINAL.
2. "A" INDICATES AMP PIN MOUNTED FROM NEARSIDE; "A*" INDICATES AMP PIN MOUNTED ON CIRCUIT SIDE.
3.
4. J INDICATES JUMPER.
5. FOR INTERCONNECTIONS REFER TO SCHEMATIC 0004-00-0060
6. NO SUBSTITUTION SHALL BE ALLOWED FOR PART INDICATED.
7. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.

rev	ecn	by	date	app
N	ECN 1241	RD	6-5-74	
G	ECN 1336	KD	3-5-74	
F	ECN 837		7-24-73	
E	ECN 724	LWH	7-17-73	
D	ECN 438	[illegible]	5-11-72	
C	ECN 413	S	4-14-72	
B	ECN 390	[illegible]	3-[illegible]-72	
A	ECN 296	RD	1-[illegible]-72	

tolerance unless otherwise specified	XXX ± 010 XX ± 030
scale	2X
material	NA
finish	NA
WAVETEK	san diego ca if
by	W MAST
date	10 NOV 69
app	
title	ASSEMBLY, POWER SUPPLY & LOGIC
model no	740
dwg no	0101-00-0133
rev	H

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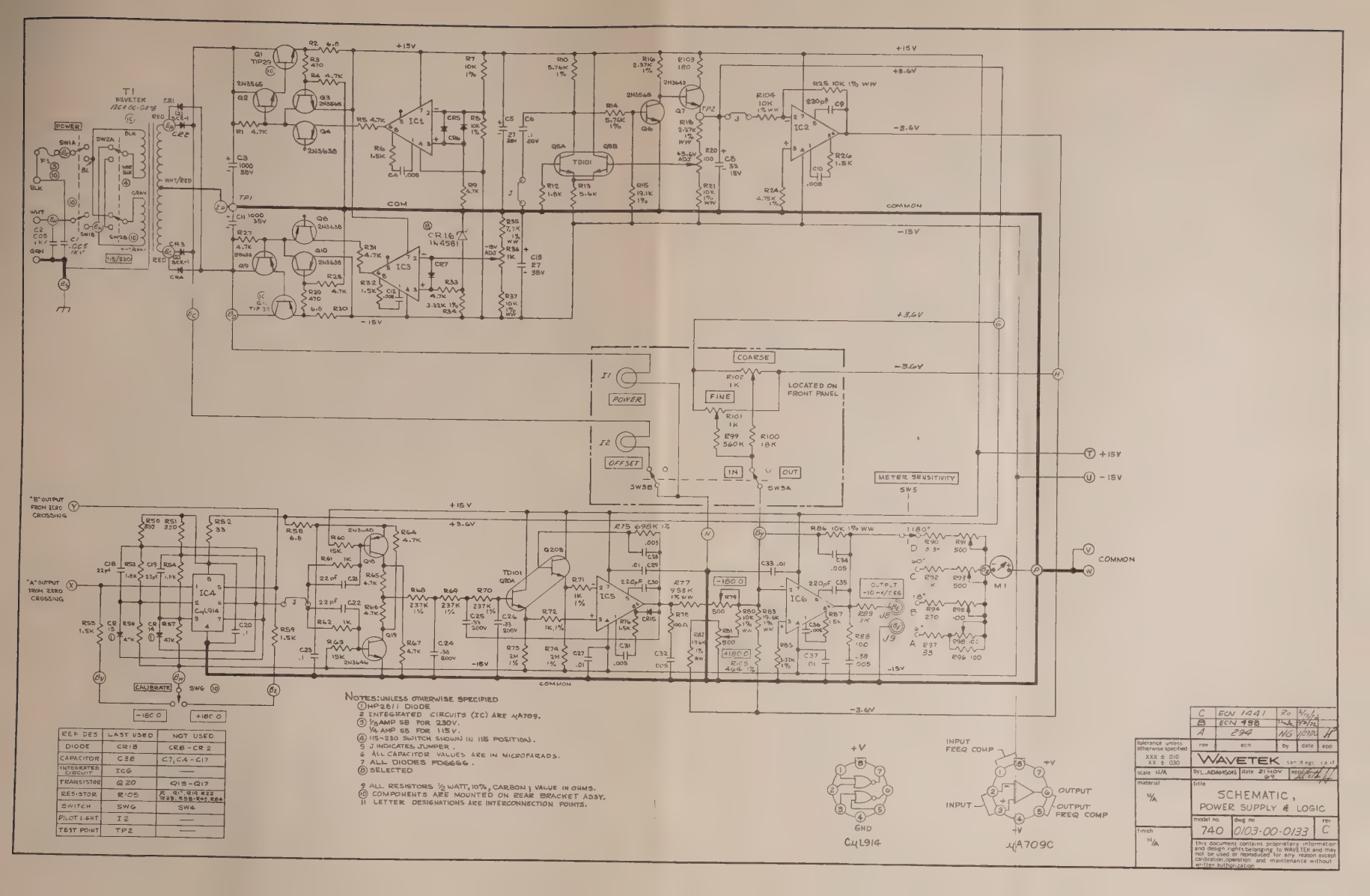

REF DES	LAST USED	NOT USED
DIODE	CR15	CR8 - CR2
CAPACITOR	C38	C7, C4 - C17
INTEGRATED CIRCUIT	IC6	——
TRANSISTOR	Q20	Q15 - Q17
RESISTOR	R105	R 91, 214, 223, 223, 238-245, 264
SWITCH	SW6	SW4
PILOT LIGHT	I2	——
TEST POINT	TP2	——

NOTES: UNLESS OTHERWISE SPECIFIED
1. HP2811 DIODE
2. INTEGRATED CIRCUITS (IC) ARE μA709.
3. ½ AMP SB FOR 230V. ¼ AMP SB FOR 115V.
4. 115-230 SWITCH SHOWN IN 115 POSITION).
5. J INDICATES JUMPER.
6. ALL CAPACITOR VALUES ARE IN MICROFARADS.
7. ALL DIODES FD6666.
8. SELECTED
9. ALL RESISTORS ½ WATT, 10%, CARBON; VALUE IN OHMS.
10. COMPONENTS ARE MOUNTED ON REAR BRACKET ASSY.
11. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.

rev	ecn	by	date	app
C	ECN 1041	RC	4/1/74	
B	ECN 988	[illegible]	2/5/74	
A	296	NG	10/1/73	

tolerance unless otherwise specified: XXX ± .010, XX ± .030
scale: N/A
material: N/A
finish: N/A
drawn: DYL. ADAMSON date 21 NOV 69
approved:

WAVETEK san diego, ca. if

title: SCHEMATIC, POWER SUPPLY & LOGIC

model no. 740 | dwg no. 0103-00-0133 | rev C

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REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DWG,LOGIC&PWR	0101-00-0133	WVTK	0101-00-0133	1
NONE	SCHEMATIC,LOGIC&PWR	0103-00-0133	WVTK	0103-00-0133	1
HS	HEAT SINK	130-331	WVTK	1400-00-1163	1
BP	INSULATOR	740-307	WVTK	1400-00-4790	1
C27 C29 C33 C37	CAP,CER,..01MF,50V	CK-103	CML	1500-01-0310	4
C2* C23 C6	CAP,CER,..1MF,20V	UK20-104	AVCO	1500-01-0413	3
C1A C19 C21 C22	CAP,CER,.22MF,1KV	DD-220	CML	1500-02-2011	4
C30 C35 C9	CAP,CER,.220PF,1KV	DD-221	CML	1500-02-2111	3
C11 C12 C28 C31 C32 C34 C36 C38 C8	CAP,CER,..005MF,50V	CK-5*2	CML	1500-05-4210	9
C31 C3	CAP,ELEC1,..100MF,45V	39D108G035GL6	SPRAG	1500-31-0212	2
C2A C25 C26	CAP,MYLAR,..33MF,200V	X663F .33MF	TRW	1500-63-3414	3
C5	CAP,TANT,.22MF,15V	196D224X9015KA1	SPRAG	1500-72-2601	1
C33 C5	CAP,TANT,.27MF,35V	196D274X0035FB	SPRAG	1500-72-7A02	2
MS	LOGIC & POWER	740-110	WVTK	1700-00-0155	1
MS	TERM,.062" LUG	14AP	SMITH	2100-04-0011	2
NONE	TERM	220591	LUCCO	2100-05-0010	6
NONE	TERM	20104	LUCCO	2100-05-0011	4

WAVETEK PARTS LIST	TITLE LOGIC & POWER	ASSEMBLY NO 1100-00-0133 PAGE: 1	REV H

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R15	RES,MF,1/8W,1%,19.1K	RN55D-1912F	TRW	4701-03-1912	1
R1A	RES,MF,1/8W,1%,2.37K	RN55D-2371F	TRW	4701-03-2371	1
R2A R69 R70	RES,MF,1/8W,1%,237K	RN55D-2373F	TRW	4701-03-2373	3
R6Q	RES,MF,1/8W,1%,274	RN55D-2740F	TRW	4701-03-2740	1
R50 R51	RES,MF,1/8W,1%,332	RN55D-3320F	TRW	4701-03-3320	2
R34 R65 R98	RES,MF,1/8W,1%,3.32K	RN55D-3321F	TRW	4701-03-3321	3
R52 R97	RES,MF,1/8W,1%,33.2	RN55D-33R2F	TRW	4701-03-3329	2
R105 R29 R3	RES,MF,1/8W,1%,464	RN55D-4640F	TRW	4701-03-4640	3
R1 R24 R27 R28 R31 R33 R4 R5 R64 R65 R66 R67 R9	RES,MF,1/8W,1%,4.75K	RN55D-4751F	TRW	4701-03-4751	13
R56 R57	RES,MF,1/8W,1%,47.5K	RN55D-4752F	TRW	4701-03-4752	2
R10 R13 R14	RES,MF,1/8W,1%,5.76K	RN55D-5761F	TRW	4701-03-5761	3
R75	RES,MF,1/8W,1%,698K	RN60D-6983F	TRW	4701-13-6983	1
R73 R74	RES,MF,1/2W,1%,2M	RN65D-2004F	TRW	4701-23-2004	2
R10A R21 R25 R37 R80 R8*	RES,MW,1/4W,1%,10M	143-14.0K	M-OHM	4702-13-1002	6
R62 R83	RES,MW,1/4W,1%,19.6K	143-19.6K	M-OHM	4702-13-1962	2
R18	RES,MW,1/4W,1%,2.37K	143-2.37K	M-OHM	4702-13-2371	1

WAVETEK PARTS LIST	TITLE LOGIC & POWER	ASSEMBLY NO. 1100-00-0133 PAGE: 3	REV H

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
IC1 IC2 IC3 IC5 IC6	IC,CLASS II,WA-709 QTY=1:17000-07-0900	130-501-14	WVTK	7200-00-0006	5
IC4	IC	ML-914	FAIR	8000-09-1400	1

WAVETEK PARTS LIST	TITLE LOGIC & POWER	ASSEMBLY NO. 1100-00-0133 PAGE: 5	REV H

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-N.	MFGR	WAVETEK NO.	QTY/PT
NONE	CONN	A0598-A	AMP	2100-05-0017	18
NONE	PIN,MALE	61182-2	AMP	2100-05-0020	18
Q1	TRANSIPAD	101231	MOTOR	2800-11-0003	8
Q4	HUBSETAL	2829-75-2	HUBST	2800-12-0005	1
R25 R95 R98	POT,TRIM,100	91AR100	BECK	4800-01-0103	3
R3A	POT,TRIM,1K	91AR1X	BECK	4800-01-0209	1
R91 R93	POT,TRIM,500	91AR500	BECK	4800-05-0108	2
R70 R81	POT,4560 F0UR1R500-05-0101	740-500-A1	WVTK	4809-80-0002	2
R2 R3U R58	RES,C,1/2W,5%,6.8	RC20GF-6R8M	STPL	4700-25-0689	1
R78 R88 R96	RES,MF,1/8W,1%,100	RN55D-1000F	TRW	4701-03-1000	3
R61 R62 R71 R89 R92 R972	RES,MF,1/8W,1%,1K	RN55D-1001F	TRW	4701-03-1001	6
R7 R8	RES,MF,1/8W,1%,10K	RN55D-1002F	TRW	4701-03-1002	2
R2A R32 R55 R59 R6 R76 R87	RES,MF,1/8W,1%,1.5K	RN55D-1501F	TRW	4701-03-1501	7
R60 R63	RES,MF,1/8W,1%,15K	RN55D-1502F	TRW	4701-03-1502	2
R12 R53 R54	RES,MF,1/8W,1%,1.78K	RN55D-1781F	TRW	4701-03-1781	3
R103	RES,MF,1/8W,1%,182	RN55D-1820F	TRW	4701-03-1820	1

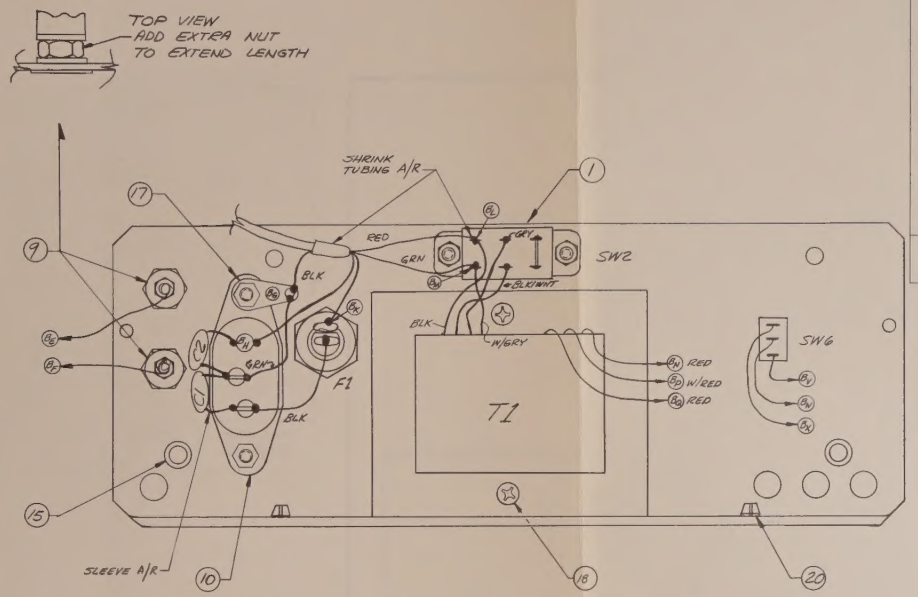
WAVETEK PARTS LIST	TITLE LOGIC & POWER	ASSEMBLY NO 1100-00-0133 PAGE: 2	REV H

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R35	RES,MW,1/4W,1%,7.7K	143-7.70K	M-OHM	4702-13-7701	1
R77	RES,MW,1/4W,1%,9.53K	143-9.53K	M-OHM	4702-13-9531	1
CR1 CR2 CR3 CR4	DIODE	8CE-1	SEMTC	4801-02-0001	4
CR15 CR5 CR6 CR7	DIODE	FD-666	FAIR	4807-02-0666	4
CR13 CR14	DIODE	50A2-2811	HP	4809-02-2811	2
CR16	DIODE,SEL,IN4581 QTY=1:14801-01-4581	740-540-39	WVTK	4898-00-0005	1
Q2 Q3 Q6	TRANS	2N3565	FAIR	4901-03-5650	3
Q10 Q4 Q8 Q9	TRANS	2N3638	FAIR	4901-03-6380	4
Q1A	TRANS	2N3640	FAIR	4901-03-6400	1
Q7	TRANS	2N3642	FAIR	4901-03-6420	1
Q1U	TRANS	2N3644	FAIR	4901-03-6440	1
Q1	TRANS	TIP-29	TI	4902-00-0290	1
Q11	TRANS	TIP-30	TI	4902-00-0300	1
Q2U Q5	TRANS	TO-101	TI	4902-00-1010	2
SW1	SWITCH ASSY PB	740-400	WVTK	5102-00-0003	1
SW5	1	740-401	WVTK	5103-00-0018	1
NONE	BUTTON	J-52105-BLACK	CRL	5103-04-0003	5

WAVETEK PARTS LIST	TITLE LOGIC & POWER	ASSEMBLY NO. 1100-00-0133 PAGE: 4	REV H

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR		TITLE POWER SUPPLY & LOGIC
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ± .010 ANGLES ±1° .XX ± .030		
	DO NOT SCALE DWG		MODEL NO 740 DWG NO 1100-00-0133 REV H
	SCALE		CODE IDENT 23338 SHEET 1 OF 1



REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DRWG, BRKT	0102-00-0334	WVTK	0102-00-0334	1
T1	TRANSFORMER	130-500	WVTK	1204-00-0078	1
1	BRKT	740-304	WVTK	1400-00-4783	1
C1 C2	CAP,CER,.005MF,1KV	DD-502	CRL	1500-05-0201	2
2	BINDING POST	111-103	EFJOH	2100-01-0004	2
10	RECEPT,POWER	LAC3G	SMCFT	2100-03-0008	1
3	TERM,LUCK LUG	1414-6	SMITH	2100-04-0009	1
4	FUSE,125V,1/4A,SB	313.250	LITFU	2400-05-0008	1
5	FUSE HOLD	345001	LITFU	2400-05-0012	1
6	SPACER	2342	SMITH	2800-04-0001	2
7	NUT,PRESS	MRPN-10-32-SCN	ROSAN	2800-09-0008	2
8	INSERT,BARC,LOC	TB10100-A32	ROOTS	2800-09-0013	2
9	PANEL NUT	120165	EFJON	2800-16-0003	2
11	SWITCH ASSY SLIDE	4025A-LF	SMCFT	5105-00-0002	1
12	SOLDER GUARD	4025A-LF-SG	SMCFT	5105-09-0001	1
SW6	SWITCH, TOGGLE	TG-3	JBT	5106-00-0001	1

WAVETEK PARTS LIST | TITLE: BRACKET ASSY | ASSEMBLY NO. 1101-00-007A | PAGE: 1 | REV

NOTES: UNLESS OTHERWISE SPECIFIED
1. FOR INTERCONNECTIONS REFER SCHEMATIC # 0004-00-0060
2. LETTER DESIGNATIONS ARE INTERCONNECTION POINTS.
3. WIRE COLORS INDICATED ARE FOR REFERENCE ONLY.

rev	ecn	by	date	app.
D	ECN 722	WJ	4/15/69	E
C	ECN 413	S	7/29/64	S
B	ECN 89	MS	10/2/62	
A	ECN 294	BH	12/6/60	

tolerance unless otherwise specified: .XXX ± .010, .XX ± .030
scale: N/A
material: N/A
finish: N/A

WAVETEK san diego, calif
by: BOCHICHIO date: 11-25-69 app:
title: ASS'Y, BRACKET
model no.: 740
dwg no.: 0102-00-0334
rev: D

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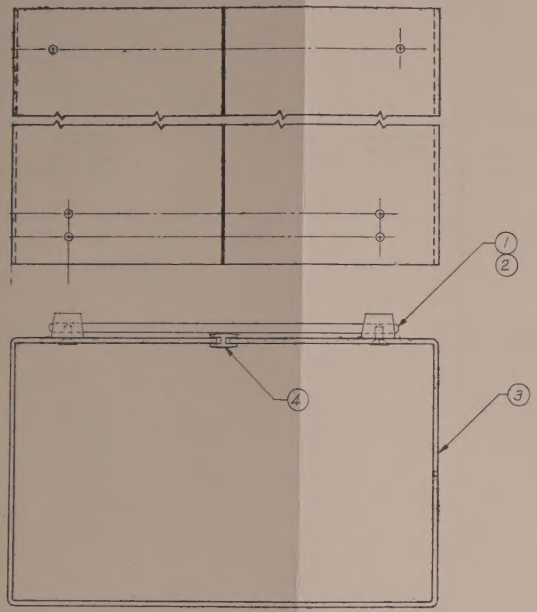
REV	ECN	BY	DATE	APP



REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
4	SUPPORT,COVER REF:3200-06-0003	130-336	WVTK	1400-00-1489	1
3	FLATS,COVER	130-353	WVTK	1400-00-1510	1
1	BAIL ASSY W/FT	130-507	WVTK	2800-08-0006	1
2	SPEEDNUT,SELF RETAIN	C7890-632-4	TINN	2800-09-0003	6

WAVETEK PARTS LIST

TITLE: COVER ASSY

ASSEMBLY NO.: 1201-00-0017

PAGE: 1

REV: A

2. BREAK ALL SHARP EDGES & CORNERS.
3. MIN BEND RADIUS TYPICAL.
NOTES:

TOLERANCE UNLESS OTHERWISE SPEC	REV	ECN	BY	DATE	APP
XXX ± .010					
XX ± .030					
ANGLES ± 0°30'					

WAVETEK SAN DIEGO, CALIF.

SCALE: FULL

BY: B. Berman DATE: 8-29-78

MATERIAL: .094 THK, GE NORYL 1000, BLACK, HAIR CELL TEXTURE (ONE SIDE)

TITLE: COVER ASSEMBLY

FINISH: NOTED

MODEL NO.: 130

DWG NO.: 1201-00-0017 SHT 2 OF 2 REV

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REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE
MATERIAL	PROJENGR	
	RELEASE APPROV.	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030	
	DO NOT SCALE DWG	
	SCALE	

WAVETEK SAN DIEGO, CALIFORNIA

TITLE: COVER

MODEL NO.: 740

DWG NO.: 1201-00-0017

REV: A

CODE IDENT: 23338

SHEET 1 OF 1

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